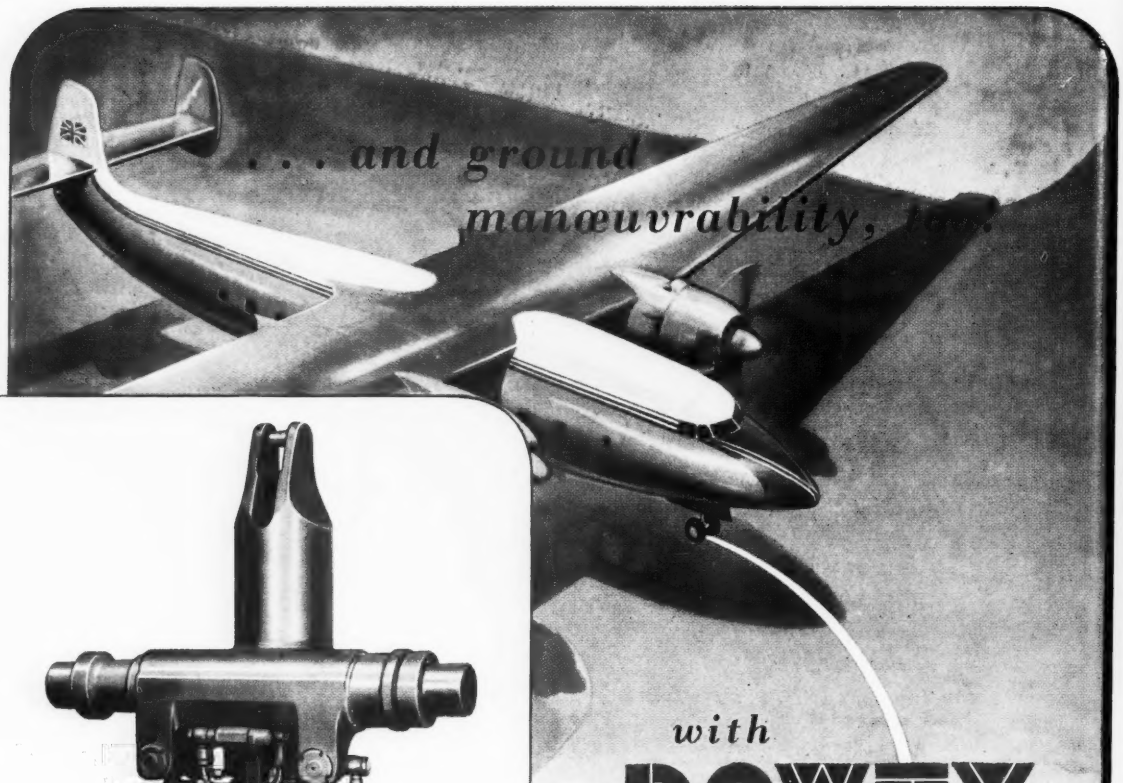
BUCKNELL UNIVERSITY LIBRARY
JAN 8 1954
LEWISBURG, PA.

DECEMBER
1903

DECEMBER
1953

Journal of
THE ROYAL AERONAUTICAL SOCIETY



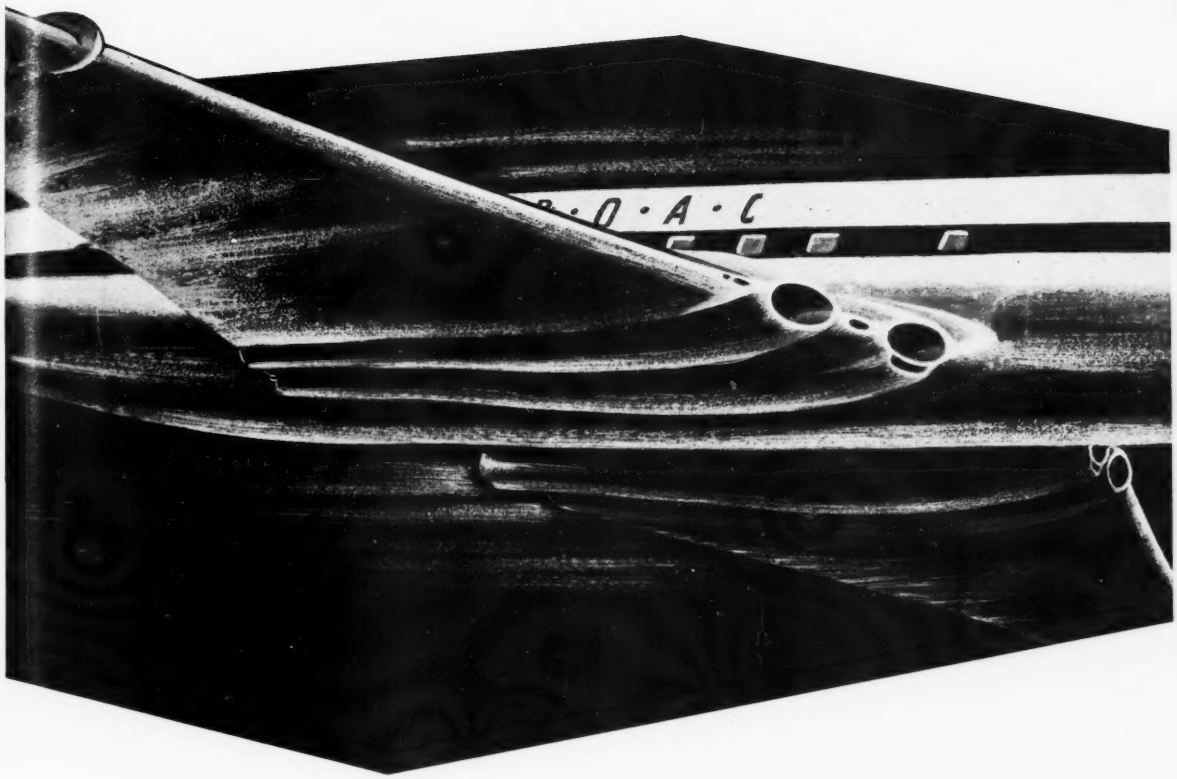
with

DOWTY

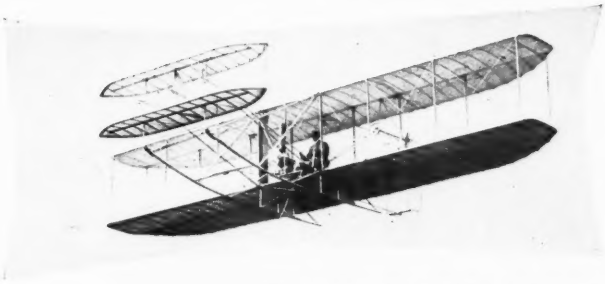
STEERABLE NOSE WHEEL

Economical and efficient air line operation is greatly influenced by ease of ground handling. On the Airspeed Ambassador this is ensured by the use of a Dowty hydraulically steered Nose Wheel.

DOWTY EQUIPMENT LIMITED · CHELTENHAM



Modern Pioneers...



Fifty years after the Wright Brothers' first flight, the aircraft industry is still pioneering. In this supersonic age, modern pioneers are continually looking ahead to days of even faster air travel. We are proud to be associated with such men of vision.

Lucas helped to equip the first British operational jet fighter in 1942, and from these beginnings continues to contribute to Britain's lead in gas turbines.

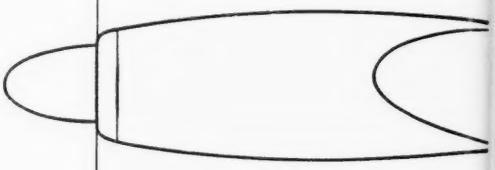
LUCAS

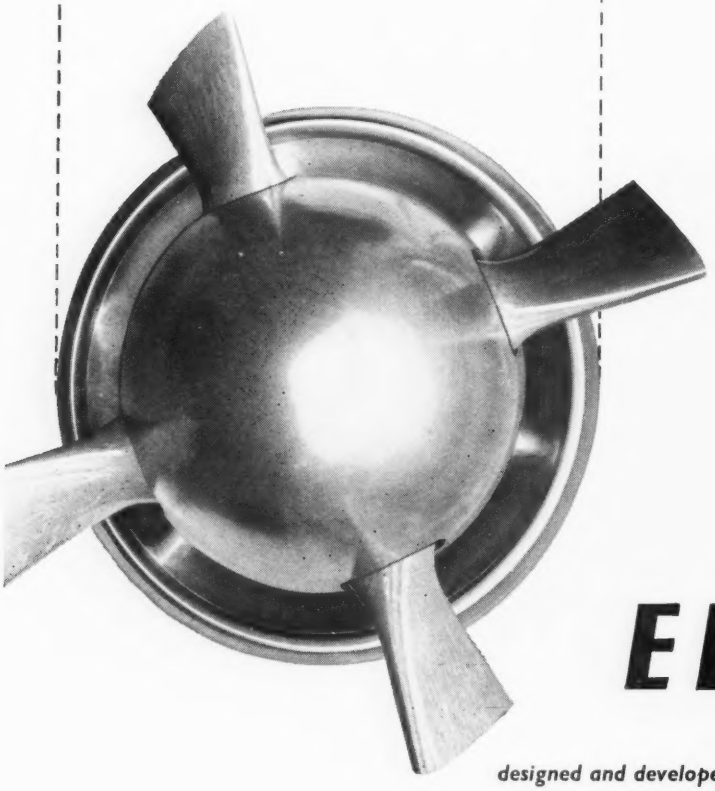
Fuel and Combustion Systems for Gas Turbine Engines

JOSEPH LUCAS (Gas Turbine Equipment) LTD., BIRMINGHAM & BURNLEY
LUCAS-ROTAX (Australia) PTY. LTD., MELBOURNE, N.3., AUSTRALIA.
LUCAS-ROTAX LTD., SCARFOROUGH, ONTARIO, CANADA.

Three thousand e.h.p. in 36"

The economies realised in the Eland design include an appreciable reduction of aerodynamic losses. The cowled diameter of 36" is very much less than has formerly been accepted for this power rating, and power plant drag is correspondingly lower.





Take off rating 3000 e.h.p.
Specific weight 0.52 lb./e.h.p.

Specific consumption 0.48 lb./b.h.p./hr. at 30,000 ft. 350 knots cruising.

Specific consumption 0.452 lb./b.h.p./hr. at 35,000 ft. 400 knots cruising.

ELAND

designed and developed by

NAPIER

ELAND ENGINES HAVE BEEN SELECTED FOR THE FAIREY ROTODYNE

D. NAPIER AND SON LIMITED · LONDON · W.3

JO

'DARVIC' polyvinyl chloride

—*the new sheet material*

★ HIGH IMPACT RESISTANCE

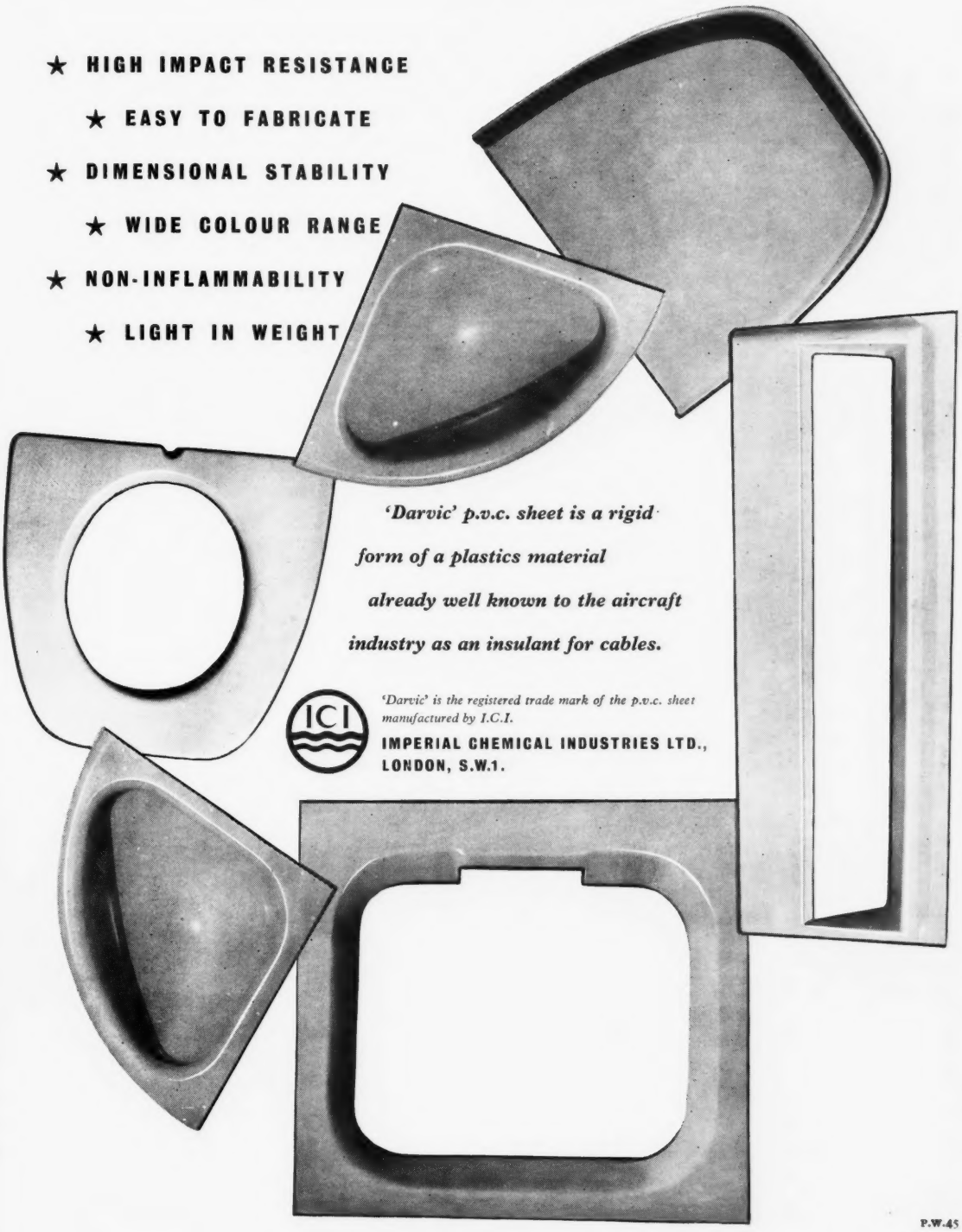
★ EASY TO FABRICATE

★ DIMENSIONAL STABILITY

★ WIDE COLOUR RANGE

★ NON-INFLAMMABILITY

★ LIGHT IN WEIGHT

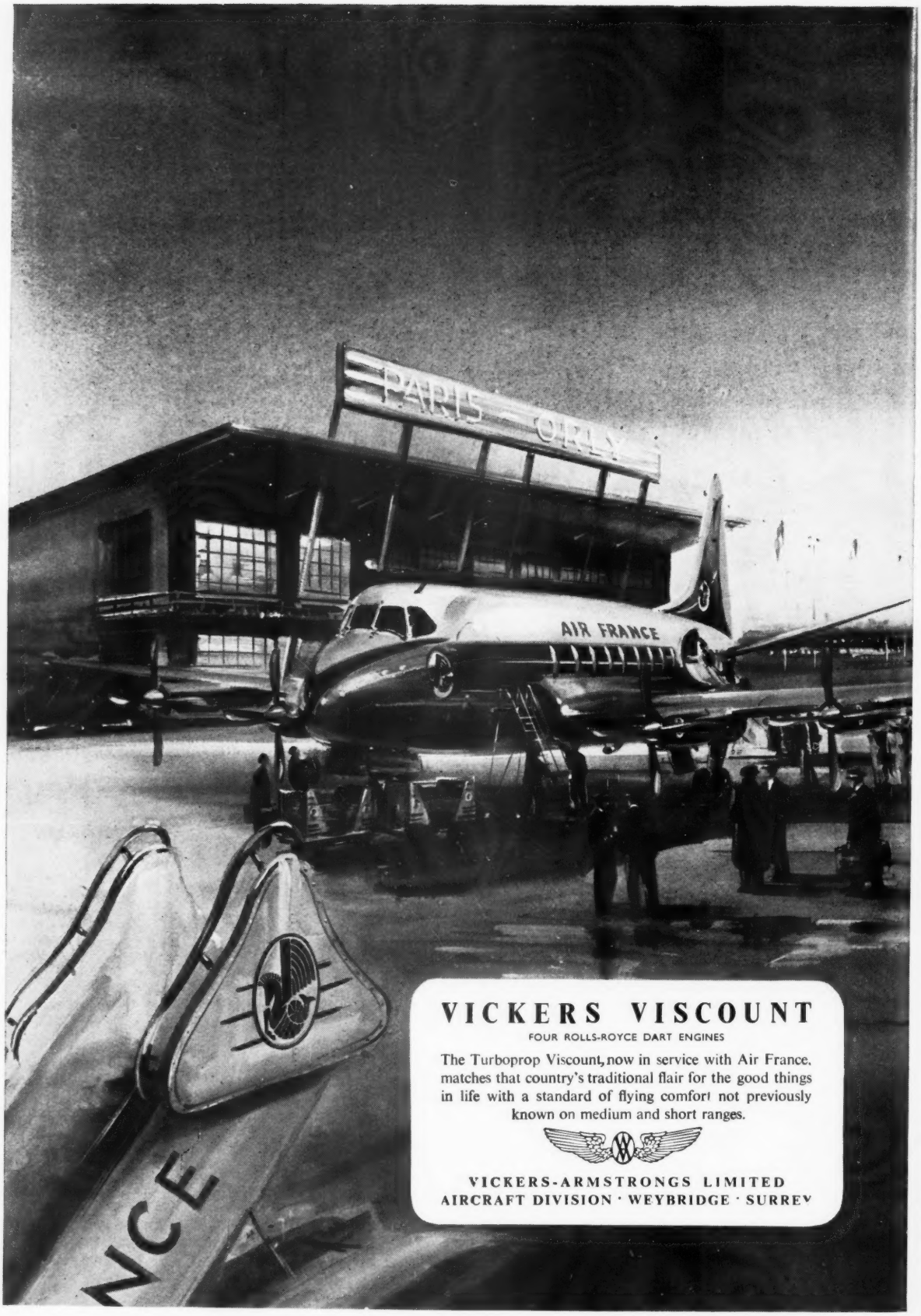


'Darvic' p.v.c. sheet is a rigid form of a plastics material already well known to the aircraft industry as an insulant for cables.

'Darvic' is the registered trade mark of the p.v.c. sheet manufactured by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1.

P.W.45



VICKERS VISCOUNT

FOUR ROLLS-ROYCE DART ENGINES

The Turboprop Viscount, now in service with Air France, matches that country's traditional flair for the good things in life with a standard of flying comfort not previously known on medium and short ranges.

VICKERS-ARMSTRONGS LIMITED
AIRCRAFT DIVISION · WEYBRIDGE · SURREY

Among the many aircraft which through the years have incorporated Vokes filtration are:—

SERVICE AIRCRAFT

ANSON
AUSTER
BALLIOL
BEAUFIGHTER
BLENHEIM
BRIGAND
BRISTOL 171
CANBERRA
DEFIANT
FIREFLY
FURY
GLADIATOR
HALIFAX
HAMPDEN
HARVARD
HASTINGS
HURRICANE
JAVELIN
KITTYHAWK
LANCASTER
LIBERATOR
LINCOLN
MAGISTER
MARTLETT
MARYLAND
MASTER
METEOR
MOHAWK
MOSQUITO
PROVOST
SEAFIRE
SHACKLETON
SKEETA
SKUA
SPITFIRE
SUNDERLAND
SWIFT
SWORDFISH
TEMPEST
TOMAHAWK
TYPHOON
VALIANT
VAMPIRE
VARSITY
VENOM
WELLINGTON
WESTLAND S.55
WHITLEY
WYVERN
WARWICK

CIVIL AIRCRAFT

AMBASSADOR
BEVERLEY
FREIGHTER
BRABAZON
BRISTOL
FREIGHTER
BRISTOL 173
BRITANNIA
COMET
DOVE
HERMES
PRINCE
PRINCESS
VIKING
VISCOUNT

VOKES

Pioneers of Scientific Filtration for the Aircraft Industry

Vokes Limited produced what is acknowledged to be the first efficient engine air-intake filter fitted to an aeroplane in any part of the world, and since that early time the influence of Vokes Filtration for air, fuel and lubricating oil, has spread throughout the Aeronautical Industry. It is not surprising, therefore, that in the new problems associated with "jet propulsion," Vokes Filtration continues to be chosen for maximum protection . . . maximum efficiency.

PISTON ENGINES
The first scientifically designed and officially approved air-intake filter for a Service aircraft engine was, and still is, solely that of Vokes manufacture. Oil and fuel filters have since been supplied for numerous famous engines.

JET ENGINES
Specified for the first Whittle Jet, Vokes have since supplied filters for a wide range of gas turbine engines.

TEST BEDS
Vokes air-intake, oil and fuel filters are pre-eminently suited for test beds and for the filtration of intake air in the test houses for both piston and gas turbines, proved by the large number installed all over the world.

HYDRAULIC LINES
Close clearance pumps and fine seating valves demand the protection that Vokes Filters alone can provide.

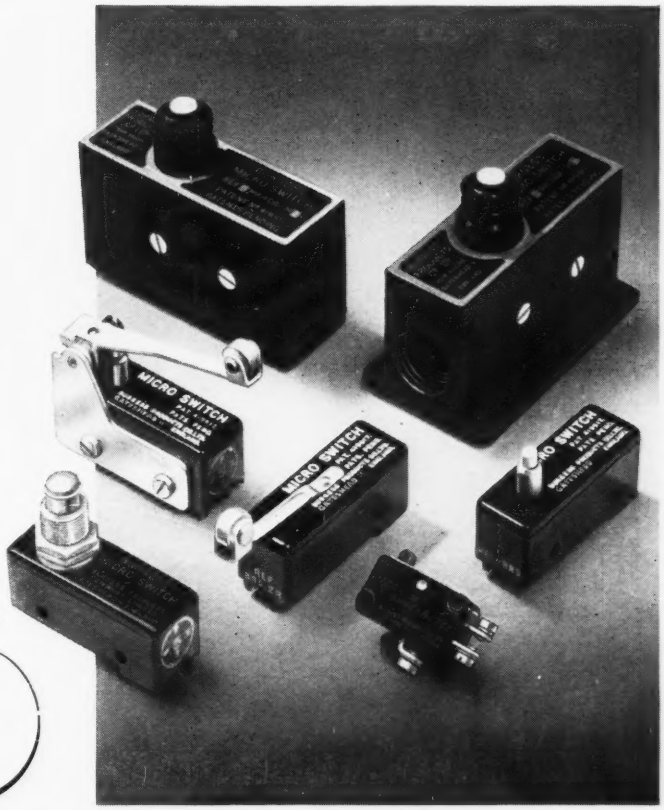
CABIN AIR SILENCING AND FILTRATION
By filtration and silencing of the pressurised system, Vokes Ltd., have made a vital contribution to the luxurious comfort of the newest airliners.

VOKES LIMITED · GUILDFORD · SURREY

V112

★ **For Automatic Switch Control**

Consult our Catalogue 50/16



BURGESS
MICRO-SWITCHES
Industry's Automatic Choice

Burgess Products Company Limited, Micro-Switch Division, Duke's Way, Team Valley, Gateshead 11. Tel.: Low Fell 75322/3

The Monomatic System of hydraulic operation for aircraft auxiliaries has the following advantages:—

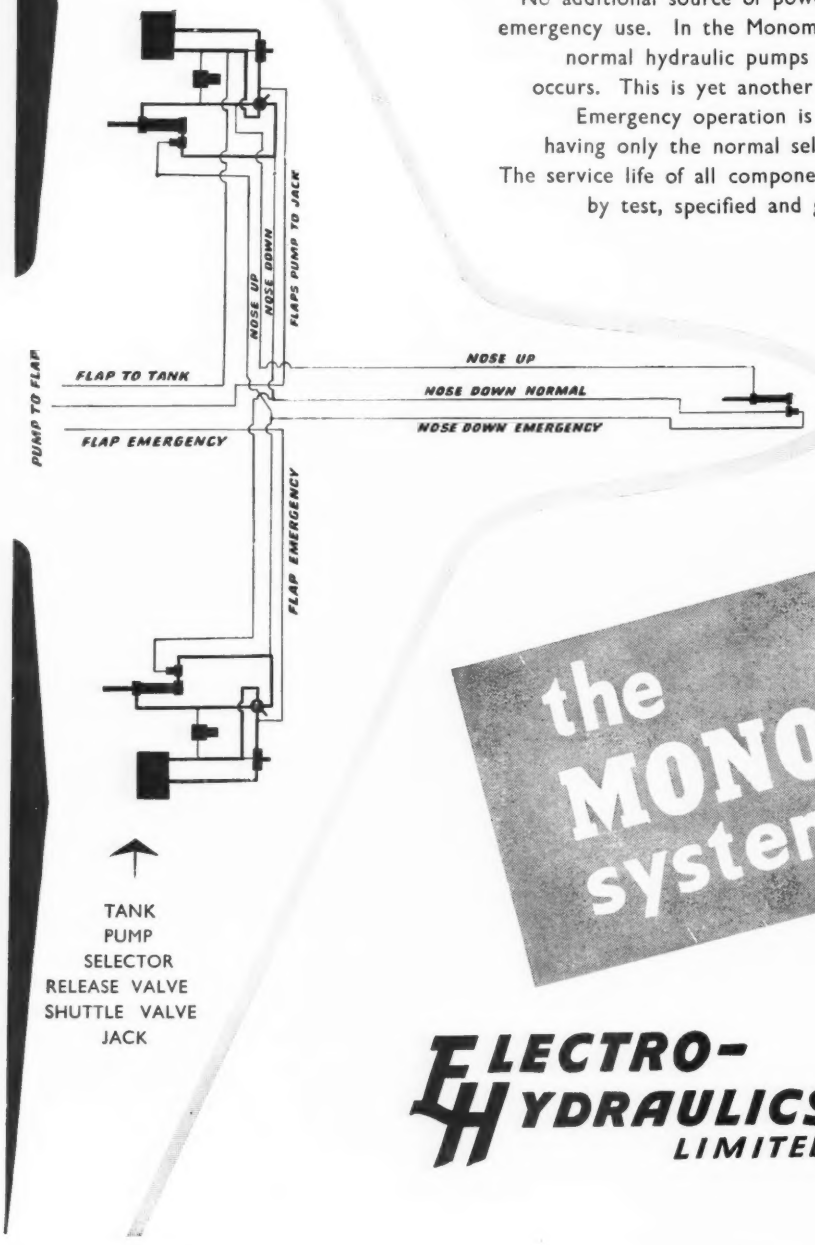
Reduction in pipe weight. No additional power supply for emergency operation. Simplicity of control. Reliability in service. Ease of maintenance.

The pumps, selectors and release valves are mounted adjacent to the ciruit demanding the highest power, giving a self-contained circuit for each service, having small lengths of pipes, low weight and small power losses. The only long pipes are those for emergency operation which are of small diameter and low weight. The saving of pipe weight may be as much as 30% compared with conventional circuits.

No additional source of power need be carried for emergency use. In the Monomatic System one of the normal hydraulic pumps takes over if a failure occurs. This is yet another weight saving feature.

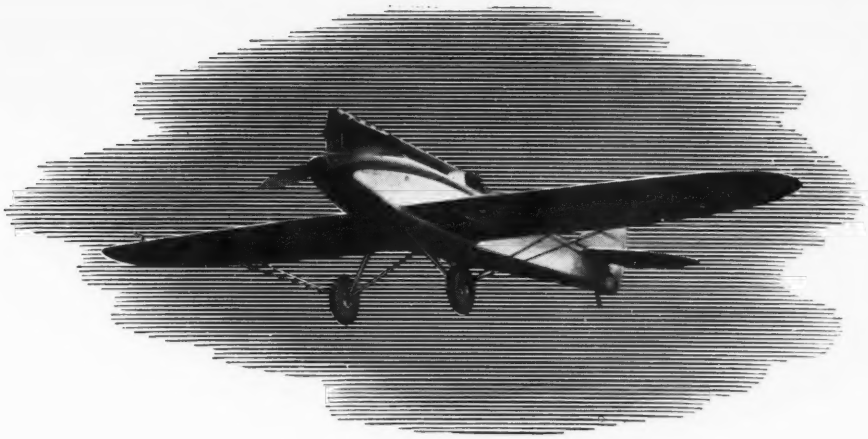
Emergency operation is automatic, the pilot having only the normal selector to operate.

The service life of all components is determined by test, specified and guaranteed.

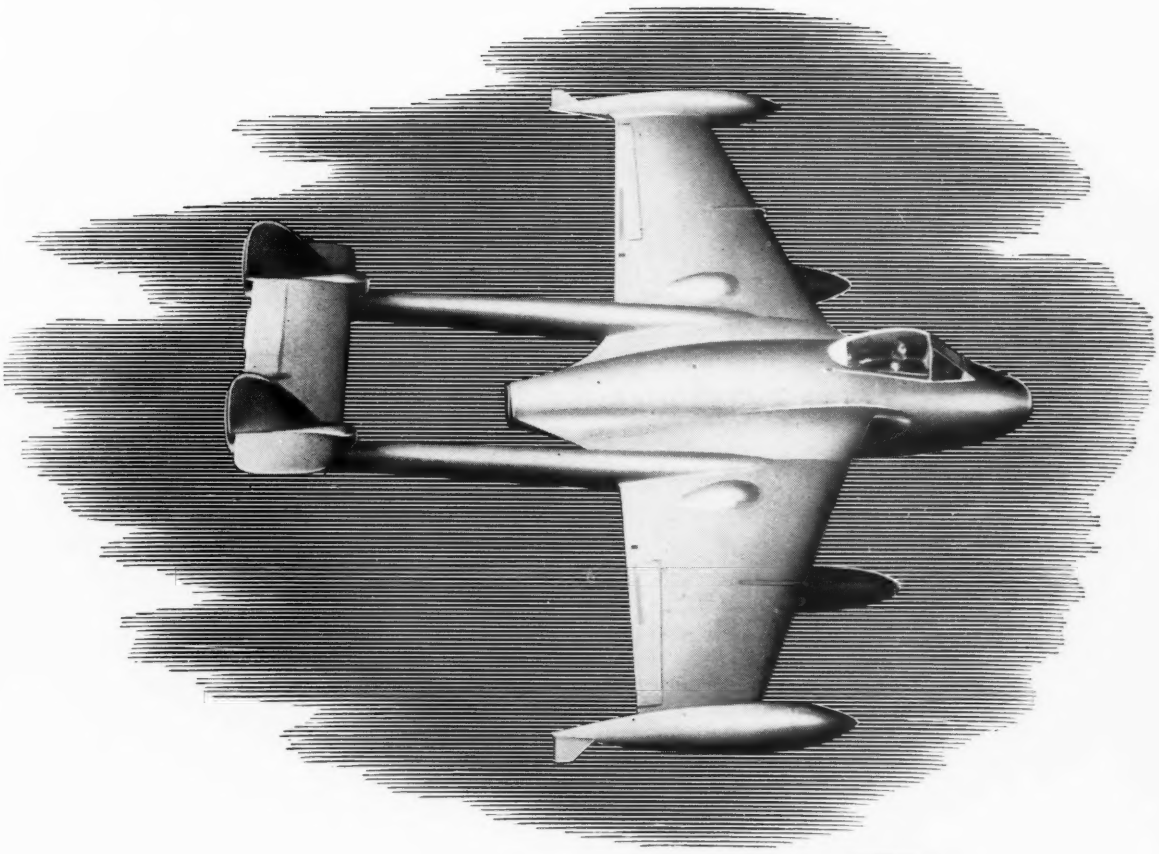


the MONOMATIC system

ELECTRO-HYDRAULICS LIMITED WARRINGTON



Then and now



DE HAVILLAND approve

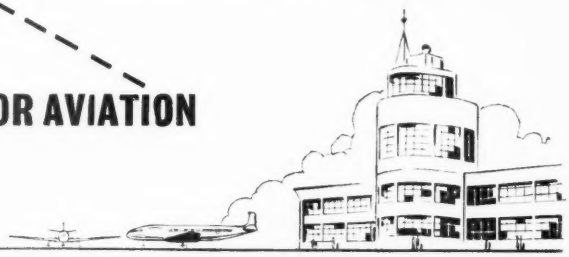
WAKEFIELD
Castrol
MOTOR OIL

in the air COOKERS · MOTORS · GENERATORS · RADIO EQUIPMENT REFRIGERATORS · HEATING AND VENTILATION · LIGHTING FITTINGS · STEWARDS CALL SYSTEMS · HEAVY ALLOY · AIRCRAFT CABLES · WATER HEATERS · URNS · OSRAM LAMPS, ETC.

on the ground AIRPORT LIGHTING AND CONTROL · GROUND TRAFFIC CONTROL · POWER EQUIPMENT AND CABLES · RADIO COMMUNICATION · NAVIGATIONAL AIDS · BROADCAST CALL SYSTEMS TELEPHONE COMMUNICATION · LIGHTING FITTINGS · HEATING AND VENTILATION · OSRAM LAMPS · COOKING EQUIPMENT AND ANY OTHER TYPE OF ELECTRICAL EQUIPMENT FOR AIRPORT BUILDINGS, ETC.

G.E.C.

ELECTRICAL EQUIPMENT FOR AVIATION



THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

Elapsed Time Clocks

BRITISH EUROPEAN AIRWAYS now fit as standard equipment the Camerer Cuss Elapsed Time Clock.

This Elapsed Time Clock was designed to an operational requirement, in conjunction with the Aircraft Development Branch of B.E.A.

To increase the safety factor on a " let-down " it was found desirable to fit this specially constructed clock to each aircraft. The instrument enables the pilot to time accurately various stages of a " let-down ", and to maintain a given rate of turn for a pre-determined time.

The clock was manufactured to a most exacting specification, a copy of which will gladly be sent on request.

We are pleased to receive enquiries for specialist timing equipment.

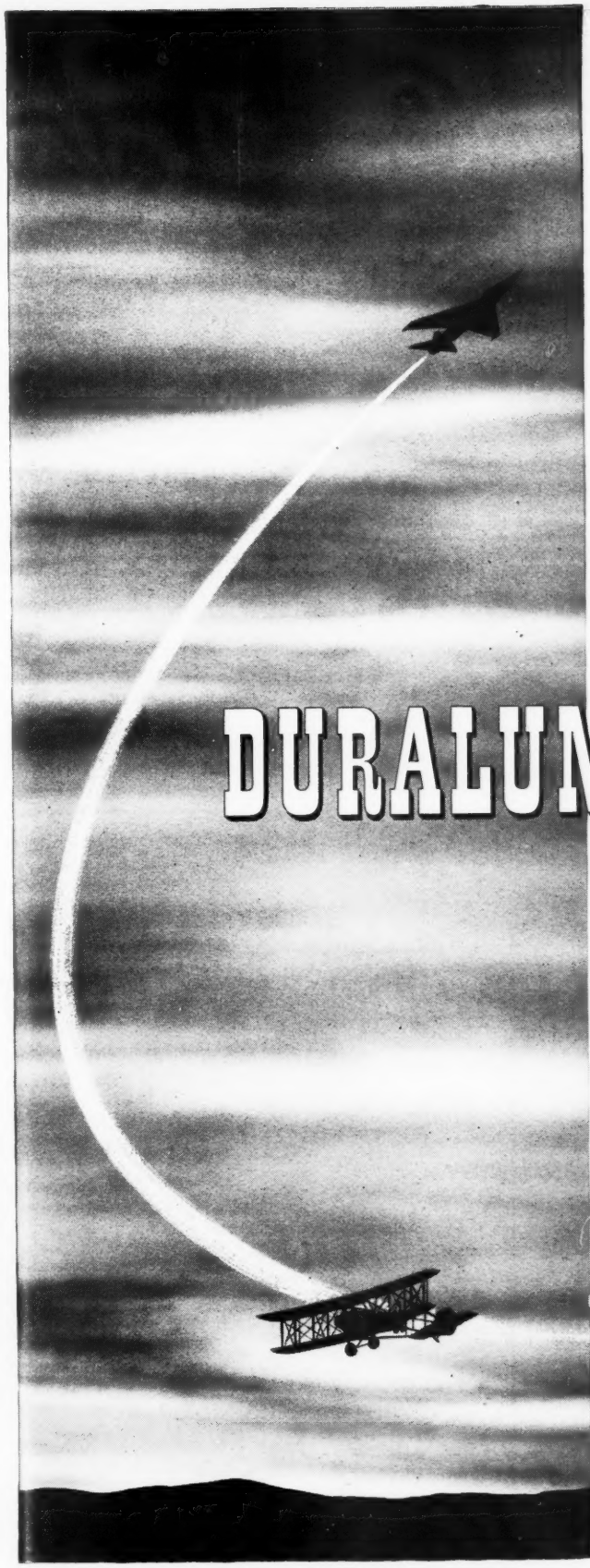
CAMERER CUSS

Makers of Good Clocks and Watches since 1788

at NEW OXFORD STREET, LONDON, W.C.1. Telephone: MUSeum 7313

Our only other address: **91 Kingsway, W.C.2**

DHB



The pioneers of strong light aluminium alloys

'DURALUMIN' is the registered trade-mark denoting the original strong, light, aluminium alloy. Its development in this country by James Booth & Company Limited made possible the first British all-metal aircraft. From the days of airships to the present time, its strength and versatility have consistently kept pace with the triumphant progress of the aircraft designer to the sonic barrier and beyond.

BOOTH BIRMINGHAM

James Booth & Co. Limited

ARGYLE STREET WORKS · BIRMINGHAM 7

The largest extrusion capacity in the country—the first to install a 12,000 ton forging press—makers of sections, tubes, sheets, plate, wire and large forgings—our technicians will be glad to advise without obligation.

HA 4A

Britain's leading aircraft rely on

MARSTON EXCELSIOR

equipment

'FLEXELITE'

FLEXIBLE FUEL TANKS WITH A HIGH SAFETY FACTOR

'MAREX'

HEAT EXCHANGERS IN LIGHT ALLOY

RADOMES

REINFORCED PLASTIC LAMINATES FOR RADOMES AND OTHER AIRCRAFT COMPONENTS

MARSTON EXCELSIOR LIMITED

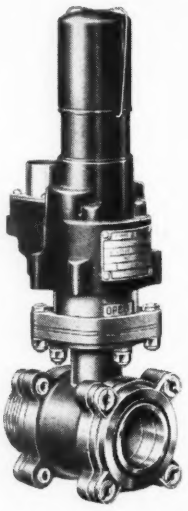
FORDHOUSES, WOLVERHAMPTON

(A subsidiary company of Imperial Chemical Industries Ltd.)

ICI

MAR 1128

Expectation of Life



After 10 years' experience on most British Service and Civil Aircraft the life of the Saunders Spherical Plug Aero Cock, before overhaul has been established as 5 years

Overhaul is simple as any part can be replaced. The ultimate life of the cock is therefore almost unlimited.

SAUNDERS AERO COCKS

Technical Literature and Installation Drawings on application

SAUNDERS VALVE COMPANY LIMITED
Aircraft Division

BLACKFRIARS STREET - HEREFORD
HEAD OFFICE: CWMBRAN, MONMOUTHSHIRE

Journal Binding

Self-binder cases of the "Easibind" type to hold 12 Journals are available from the offices of the Society at 11/6, including postage and packing. The binders are in two sizes—to fit the 1952 and previous Journals or to fit the new size Journal.

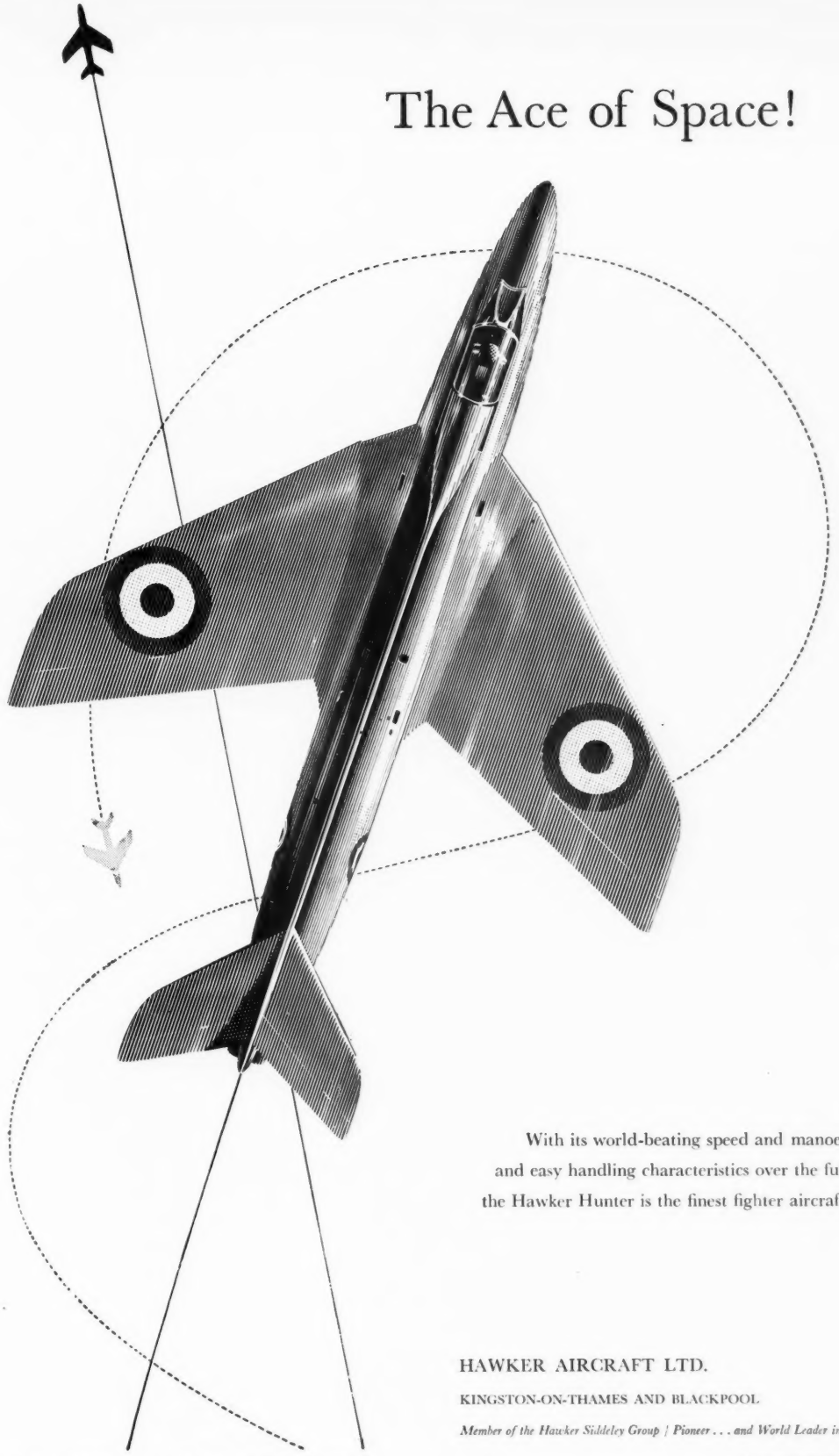
Orders and remittances for the "Easibind" cases, stating the size required, should be sent direct to the Secretary.

The price of permanent binding is 17/6 for the 1953 Volume and 18/- for previous volumes. Journals for permanent binding should be sent **with name and address,** to The Lewes Press, Friars Walk, Lewes, Sussex, and the remittance to the Secretary at the Society.

ROYAL AERONAUTICAL SOCIETY

4 Hamilton Place, London, W.1

The Ace of Space!



With its world-beating speed and manoeuvrability,
and easy handling characteristics over the full speed range,
the Hawker Hunter is the finest fighter aircraft ever produced.

HAWKER AIRCRAFT LTD.

KINGSTON-ON-THAMES AND BLACKPOOL

Member of the Hawker Siddeley Group | Pioneer . . . and World Leader in Aviation

CHAPMAN & HALL

Published under the authority of the Royal Aeronautical Society

ADHESIVES FOR WOOD

by R. A. G. KNIGHT, B.SC., M.I.MECH.E.

Demy 8vo 256 *pages* 19 *figures* 6 *plates* 25*s. net* (*Published March* 1952)

THE PROPERTIES OF METALLIC MATERIALS AT LOW TEMPERATURES

by P. LITHERLAND TEED, F.R.AE.S.

Demy 8vo 232 *pages* 8 *figures* 22*s. 6d. net* (*Published* 28*th April* 1950) (*Second Impression* 1952)

THE STRUCTURE AND MECHANICAL PROPERTIES OF METALS

by BRUCE CHALMERS, D.SC., F.INST.P.

Demy 8vo 132 *pages* 89 *figures* 18*s. net* (*Published* 18*th January* 1951) (*Second Impression* 1953)

MASSBALANCING OF AIRCRAFT CONTROL SURFACES

by H. TEMPLETON, B.SC., F.R.AE.S.

In the Press

Other Titles in Preparation

37 ESSEX STREET, LONDON, W.C.2

DATA SHEETS ON STRUCTURES

A further issue of new and revised sheets in the well known Structures Data Sheets has just been made

THE NEW SHEETS INCLUDE GROUPS ON:

Stress distribution in non-rigid fuselage frames

Flat plates under normal pressure

Stress analysis of curved panels in shear

Various other sheets have been brought into line with latest theory

THESE SHEETS HAVE BEEN SENT TO ALL HOLDERS OF STRUCTURES DATA SHEETS. THEY ARE NOT AVAILABLE INDIVIDUALLY. FULL DETAILS OF THE COMPLETE SERIES CAN BE OBTAINED FROM:-

THE ROYAL AERONAUTICAL SOCIETY

4 HAMILTON PLACE · LONDON W1

YOU'RE AN

We've just caught Mr. Paget hogging the bathroom in a Milan hotel. Next week he'll be doing the same in Madrid. The week after, he'll be at it in Stockholm. Altogether Mr. Paget travels as far and as fast as any mythical fairy godmother. But that's not why he is one. The real reason ?

AIRY GODMOTHER,

Simply that Mr. Paget—like 1¼ million others last year—flies by BEA. And his fare money does a lot to keep British Civil Aviation where it is—at the top. It enables BEA to buy new British aircraft (such as the Viscount), and to order more. It enables them to lend their advice as

MR. PAGET

operators to the aircraft manufacturers to give the user's side of the story. Though he doesn't know it, Mr. Paget is doing a pretty big job to help. And the more there are like him, the brighter the future for British flying.

fly British ***keep British aircraft ahead***

BEA

fly **BEA**

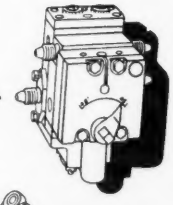
BRITISH EUROPEAN AIRWAYS

DUNLOP

Serves the Aircraft Industry with . . .

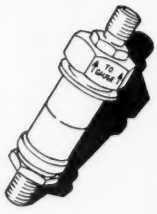
ACCUMULATORS *for high pressure hydraulic systems.*

MARK III **BRAKE CONTROLS** *suitable for differential braking circuits.*

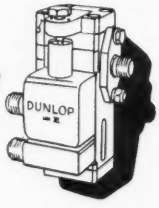


MASTER CYLINDERS *for small self-contained brake systems.*

PRESSURE RELAY VALVES *designed to prevent loss of fluid in the event of failure of subsidiary circuits.*

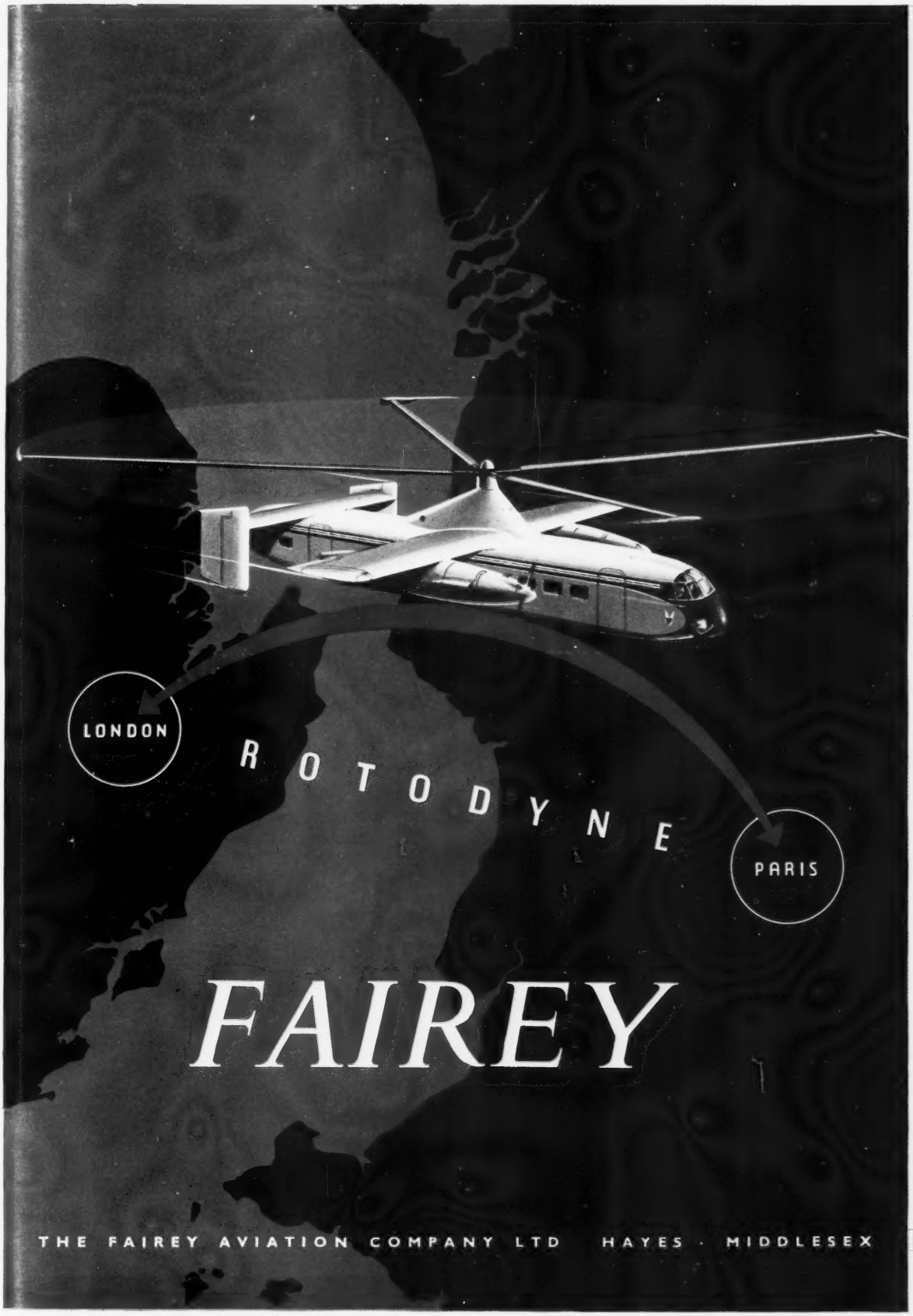


PRESSURE REDUCING VALVES *to step down system pressure to the requirements of individual circuits.*



Enquiries to the Dunlop Rubber Co. Ltd. (Aviation Division), Foleshill, Coventry

3H/611

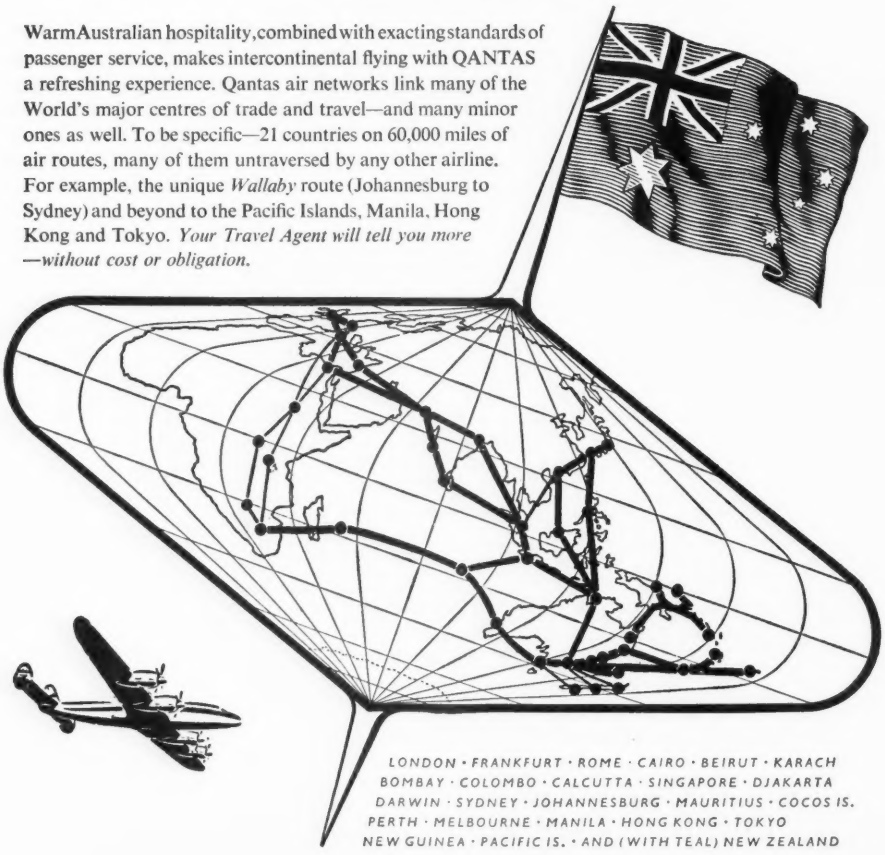

LONDON
ROTODYNE
PARIS
FAIREY
THE FAIREY AVIATION COMPANY LTD HAYES · MIDDLESEX

FOR VALUE AND VARIETY
IN WORLD AIR TRAVEL

FLY AUSTRALIAN*

to any of 21 Countries

Warm Australian hospitality, combined with exacting standards of passenger service, makes intercontinental flying with QANTAS a refreshing experience. Qantas air networks link many of the World's major centres of trade and travel—and many minor ones as well. To be specific—21 countries on 60,000 miles of air routes, many of them untraversed by any other airline. For example, the unique *Wallaby* route (Johannesburg to Sydney) and beyond to the Pacific Islands, Manila, Hong Kong and Tokyo. *Your Travel Agent will tell you more —without cost or obligation.*



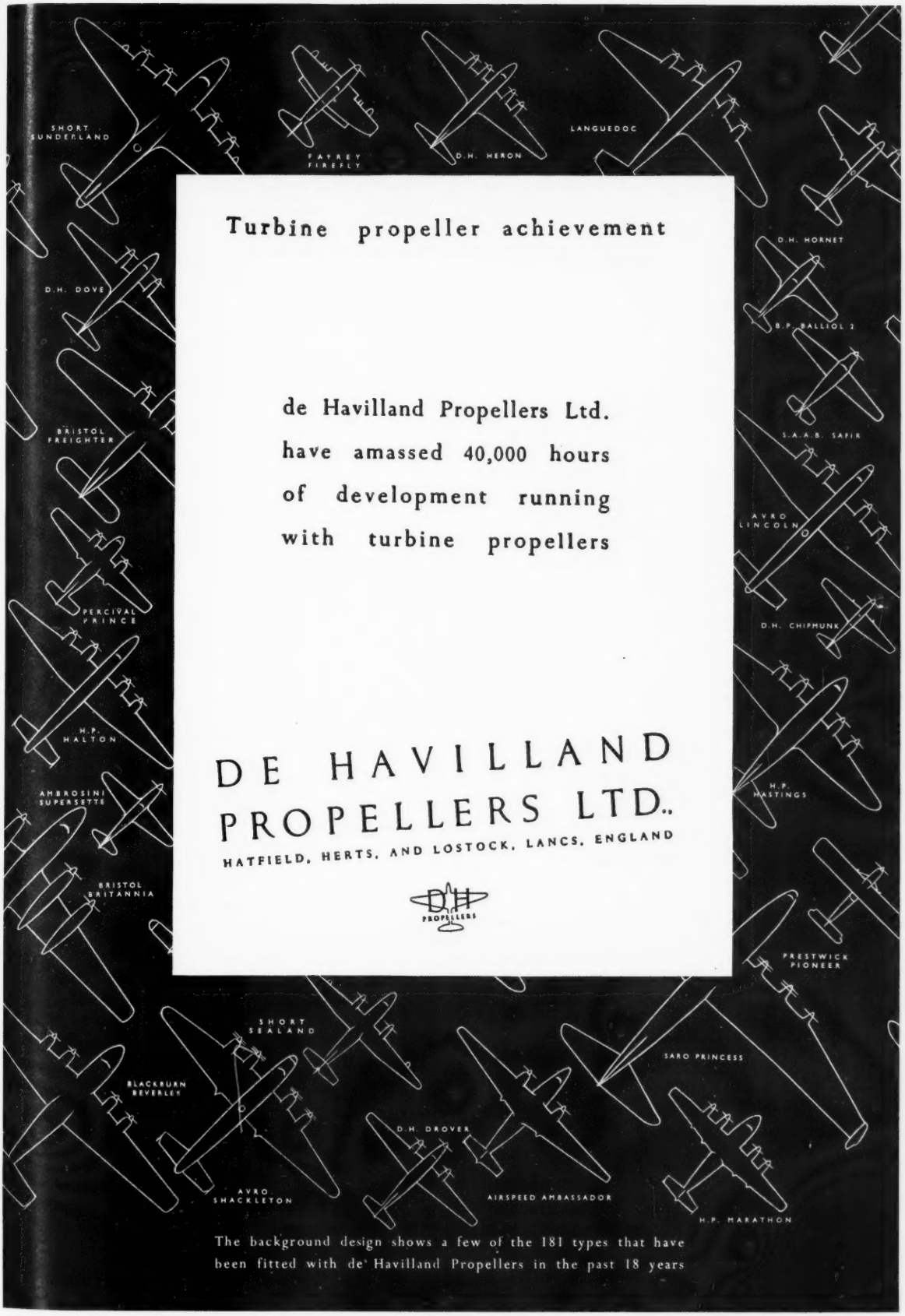
LONDON · FRANKFURT · ROME · CAIRO · BEIRUT · KARACH
BOMBAY · COLOMBO · CALCUTTA · SINGAPORE · DJAKARTA
DARWIN · SYDNEY · JOHANNESBURG · MAURITIUS · COCOS IS.
PERTH · MELBOURNE · MANILA · HONG KONG · TOKYO
NEW GUINEA · PACIFIC IS. · AND (WITH TEAL) NEW ZEALAND

FLY* QANTAS

AUSTRALIA'S OVERSEAS AIRLINE
—and one of the World's first!

PASSENGER ENQUIRIES : 69 PICCADILLY · W1 · MAYFAIR 9200

Qantas Empire Airways Limited in association with British Overseas Airways Corporation and Tasman Empire Airways Limited



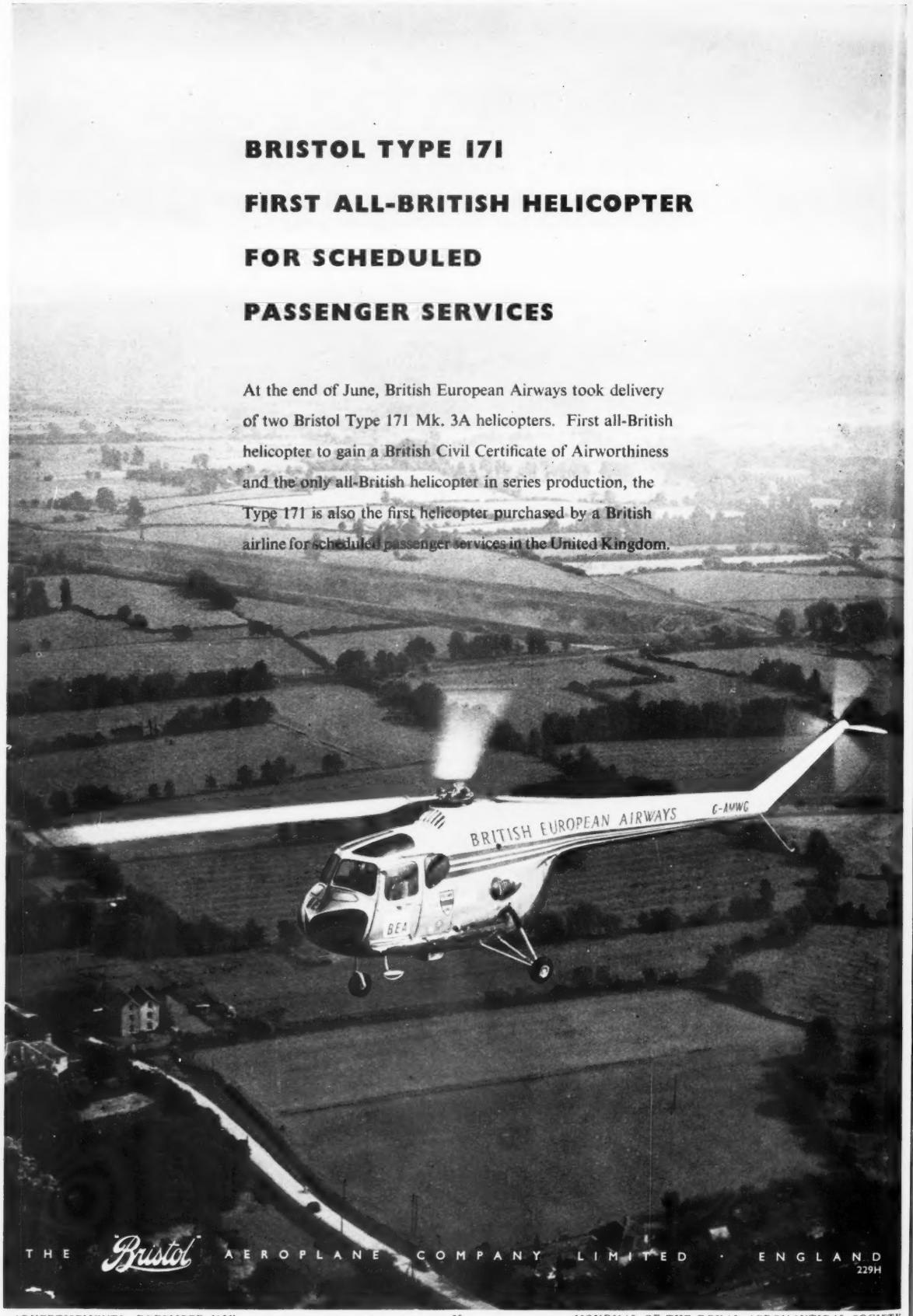
Turbine propeller achievement

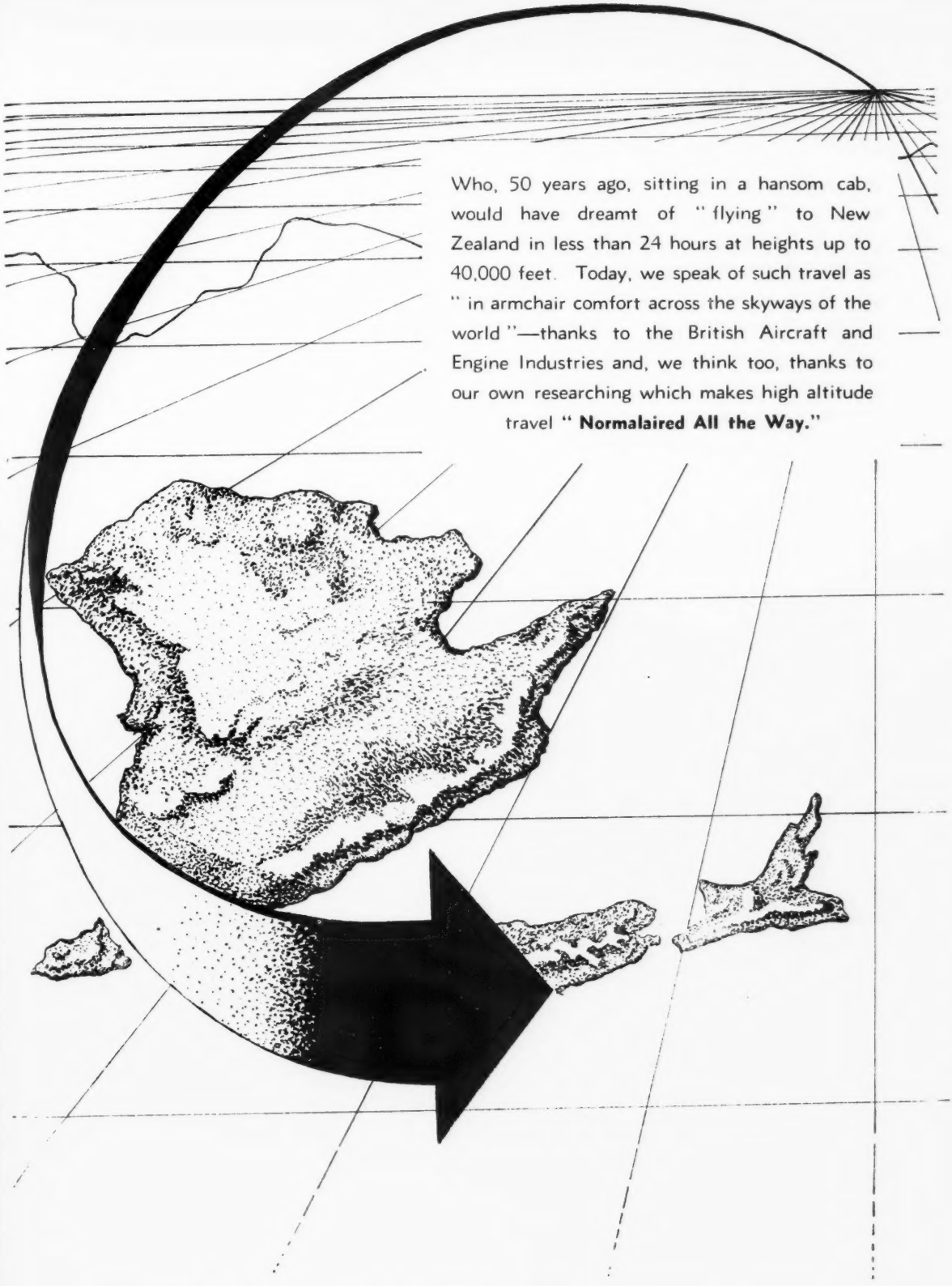
de Havilland Propellers Ltd. have amassed 40,000 hours of development running with turbine propellers

DE HAVILLAND PROPELLERS LTD.

HATFIELD, HERTS, AND LOSTOCK, LANCS, ENGLAND

The background design shows a few of the 181 types that have been fitted with de Havilland Propellers in the past 18 years


BRISTOL TYPE 171
FIRST ALL-BRITISH HELICOPTER
FOR SCHEDULED
PASSENGER SERVICES
At the end of June, British European Airways took delivery of two Bristol Type 171 Mk. 3A helicopters. First all-British helicopter to gain a British Civil Certificate of Airworthiness and the only all-British helicopter in series production, the Type 171 is also the first helicopter purchased by a British airline for scheduled passenger services in the United Kingdom.
BRITISH EUROPEAN AIRWAYS
G-AMWG
BEA
THE Bristol AEROPLANE COMPANY LIMITED · ENGLAND
229H



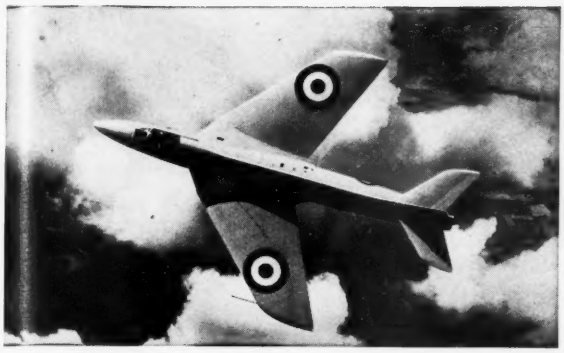
Who, 50 years ago, sitting in a hansom cab, would have dreamt of "flying" to New Zealand in less than 24 hours at heights up to 40,000 feet. Today, we speak of such travel as "in armchair comfort across the skyways of the world"—thanks to the British Aircraft and Engine Industries and, we think too, thanks to our own researching which makes high altitude travel **"Normalaired All the Way."**

NORMALAIR LTD · WEST HENDFORD · YEOVIL · ENGLAND

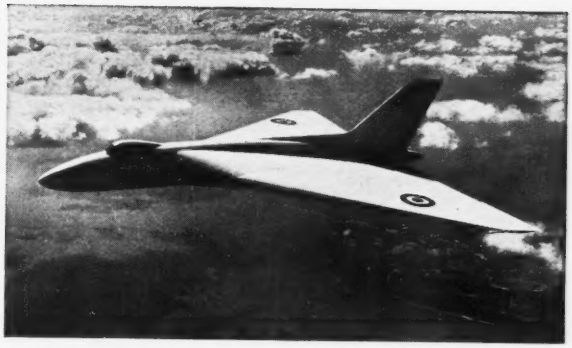
Pioneer and World Leader in Aviation

On December 17th, 1903, Orville Wright flew the Wright Bros. bi-plane. The flight lasted only 12 seconds and covered only 120 feet, but it made history. For this was the first powered heavier-than-air machine ever to defy the laws of gravity and fly. Since then many machines have won themselves a niche in the annals of aviation . . . and a surprising number of them have been made by companies forming the great Hawker Siddeley Group. Think for one minute of the famous aeroplanes you instinctively remember. The Sopwith 'Pup' and the 'Camel'; heroes of World War I. The Gloster 'Gladiator' and the Hawker 'Fury' of the years between the wars. The Hawker 'Hurricane' and the Avro 'Lancaster'; immortals of World War II. All these were Group products. And what of today? The Hawker Siddeley Group fully maintains its proud slogan "Pioneer and World Leader". Here are just a few of the Group products now in full-scale production for the R.A.F. and N.A.T.O. All of them the finest examples of their class in the world today.

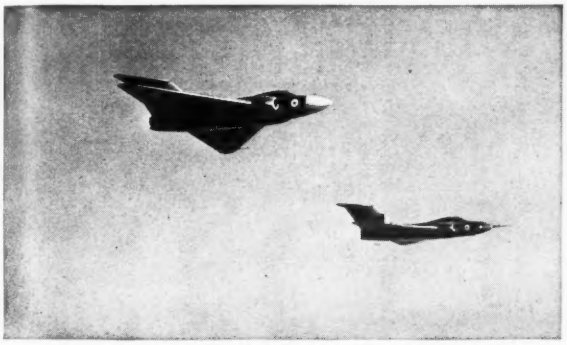
A. V. ROE · GLOSTER · ARMSTRONG WHITWORTH · HAWKER · AVRO CANADA · ARMSTRONG SIDDELEY



HAWKER HUNTER. *First choice of RAF and NATO, this superb interceptor, "finest fighting aircraft in the world", is super-sonic, heavily armed and extremely manœuvrable. Now in super-priority production.*

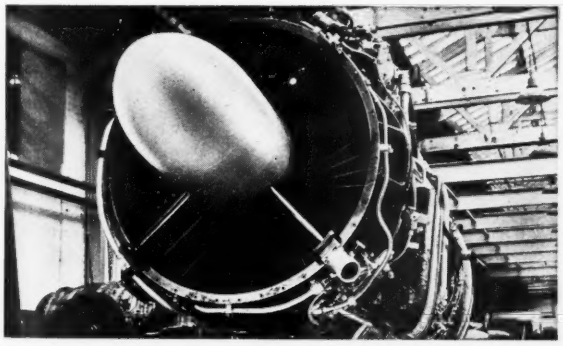


AVRO VULCAN. *Beginning with the famous experimental 707s, Avro has pioneered the Delta planform, magnificently displayed in this Vulcan four-jet bomber now in super-priority production for the RAF.*

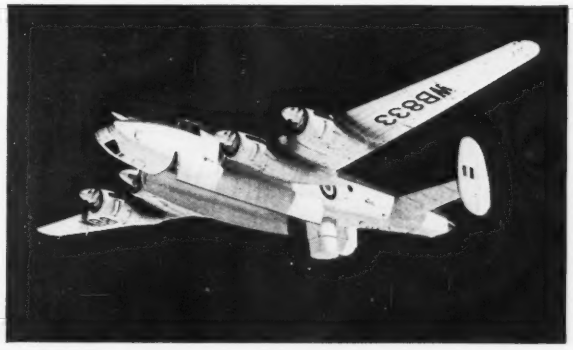


GLOSTER JAVELIN. *Now in super-priority production for the RAF, this twin-jet all-weather Delta fighter is considered to be the vital key in both Britain's and Europe's atomic defence system.*

SEA HAWK. *First deliveries of this first-line jet fighter have already been made to Naval squadrons. In addition to orders for the Royal Navy, American off-shore contracts have been placed.*



ARMSTRONG SIDDELEY SAPPHIRE TURBO-JET. *Super-priority orders call for the Sapphire in the Hawker Hunter and Gloster Javelin. The Sapphire is also in production at Curtiss Wright in U.S.A.*

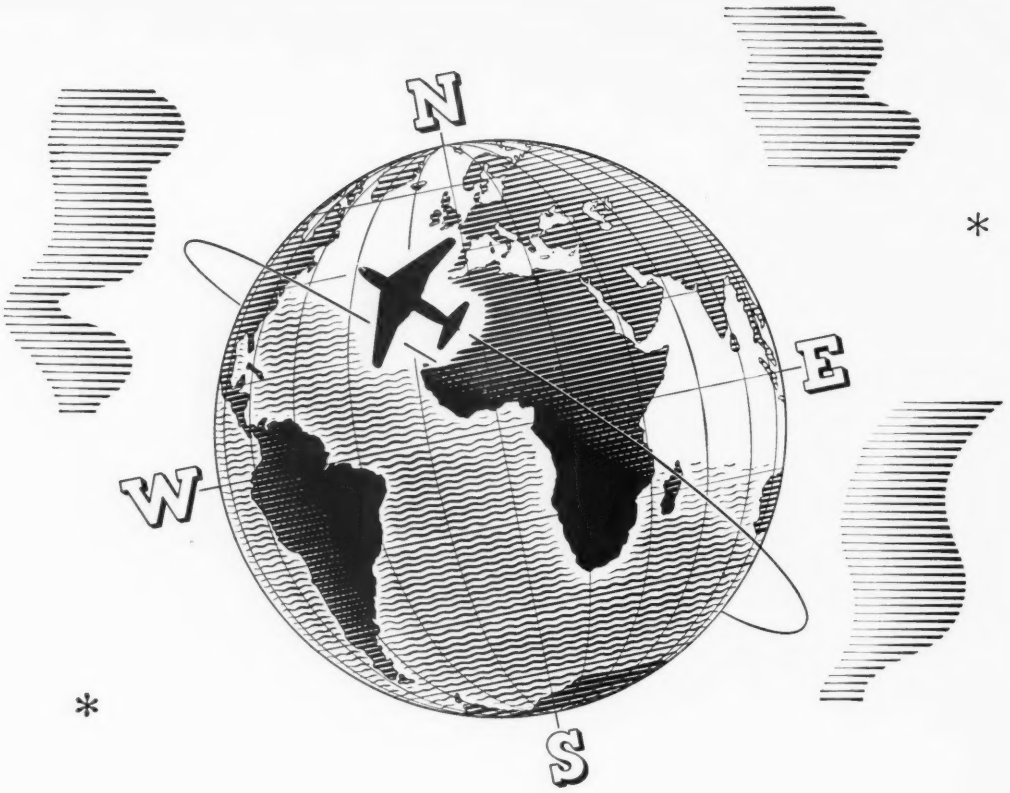


AVRO SHACKLETON. *Now in squadron service with the RAF, the Avro Shackleton Mark II sets a new standard of performance for very long range ocean patrol and anti-submarine warfare.*

Hawker Siddeley Group

18 ST. JAMES'S SQUARE, LONDON, S.W.1.

HAWKSLEY · BROCKWORTH ENGINEERING · AIR SERVICE TRAINING · HIGH DUTY ALLOYS



B.O.A.C. flies to all six continents

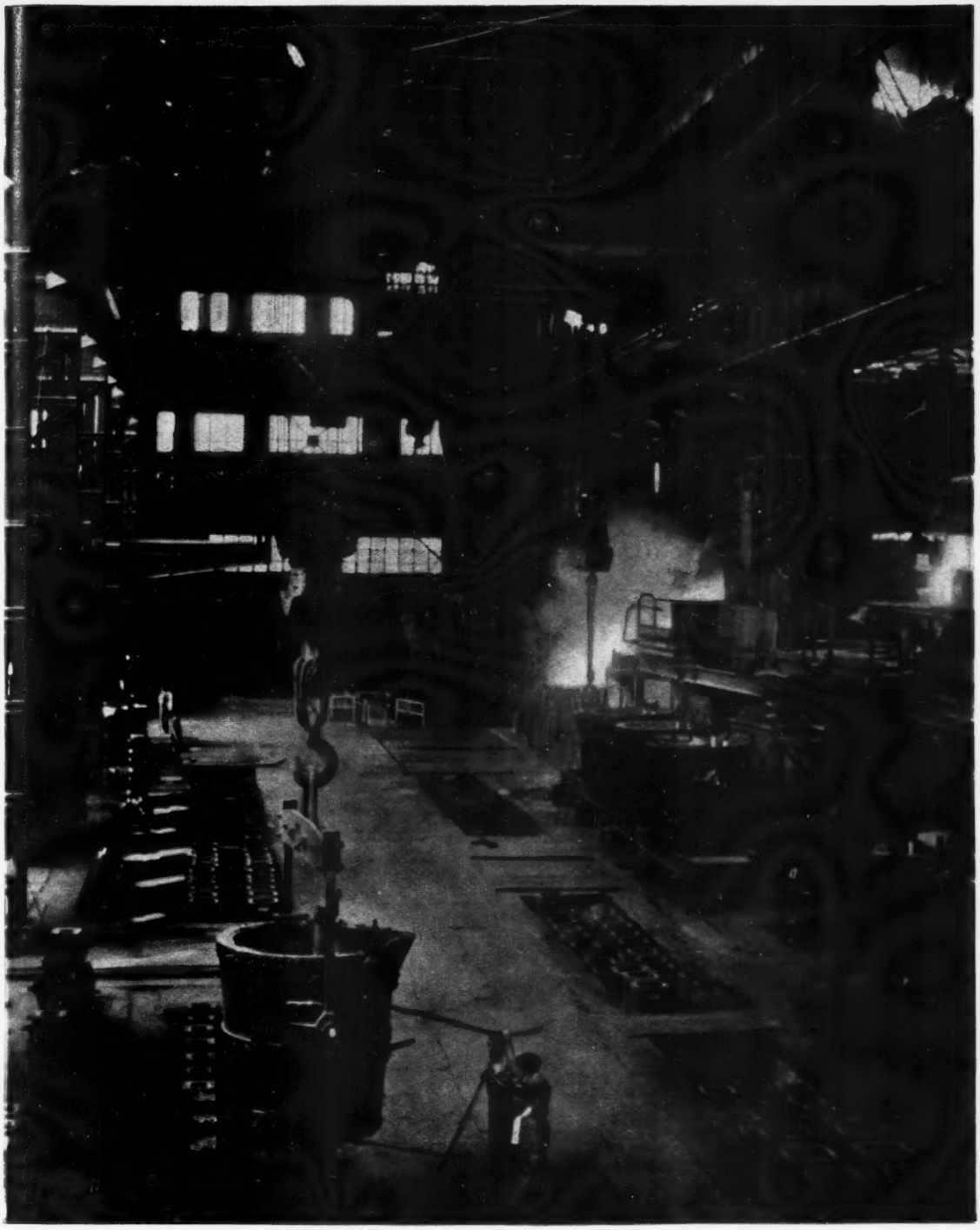
GREAT BRITAIN · USA · SPAIN · PORTUGAL · SWITZERLAND · GERMANY
ITALY · BERMUDA · BAHAMAS · CANADA · WEST INDIES · SOUTH AMERICA
MIDDLE EAST · WEST AFRICA · EAST AFRICA · SOUTH AFRICA · PAKISTAN
INDIA · CEYLON · AUSTRALIA · NEW ZEALAND · FAR EAST · JAPAN

B.O.A.C. TAKES GOOD CARE OF YOU

Consult your local B.O.A.C. Appointed Agent or B.O.A.C., Airways Terminal, S.W.1 (VIC 2323), 75 Regent Street, W.1 (MAY 6611) or offices in Glasgow, Manchester, Birmingham and Liverpool.

FLY BRITISH BY B·O·A·C

BRITISH OVERSEAS AIRWAYS CORPORATION IN ASSOCIATION WITH QANTAS EMPIRE AIRWAYS LIMITED, SOUTH AFRICAN AIRWAYS AND TASMAN EMPIRE AIRWAYS LIMITED



Electric Melting Shop

FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · HEAVY ENGINEERS

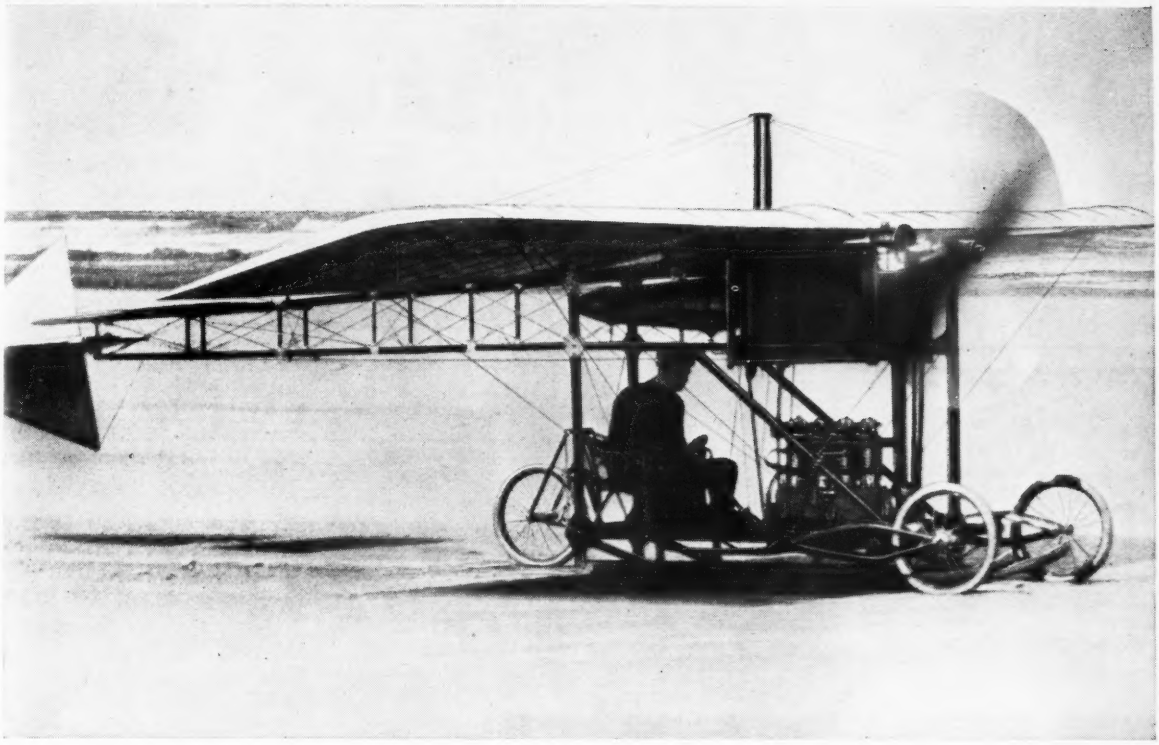
THOS. FIRTH & JOHN BROWN LIMITED · SHEFFIELD

Stainless and Special Steels for the Aircraft Industry

Low Moor Alloy Steelworks Ltd. LOW MOOR, BRADFORD

Telephone: Low Moor 663 (Ten lines)

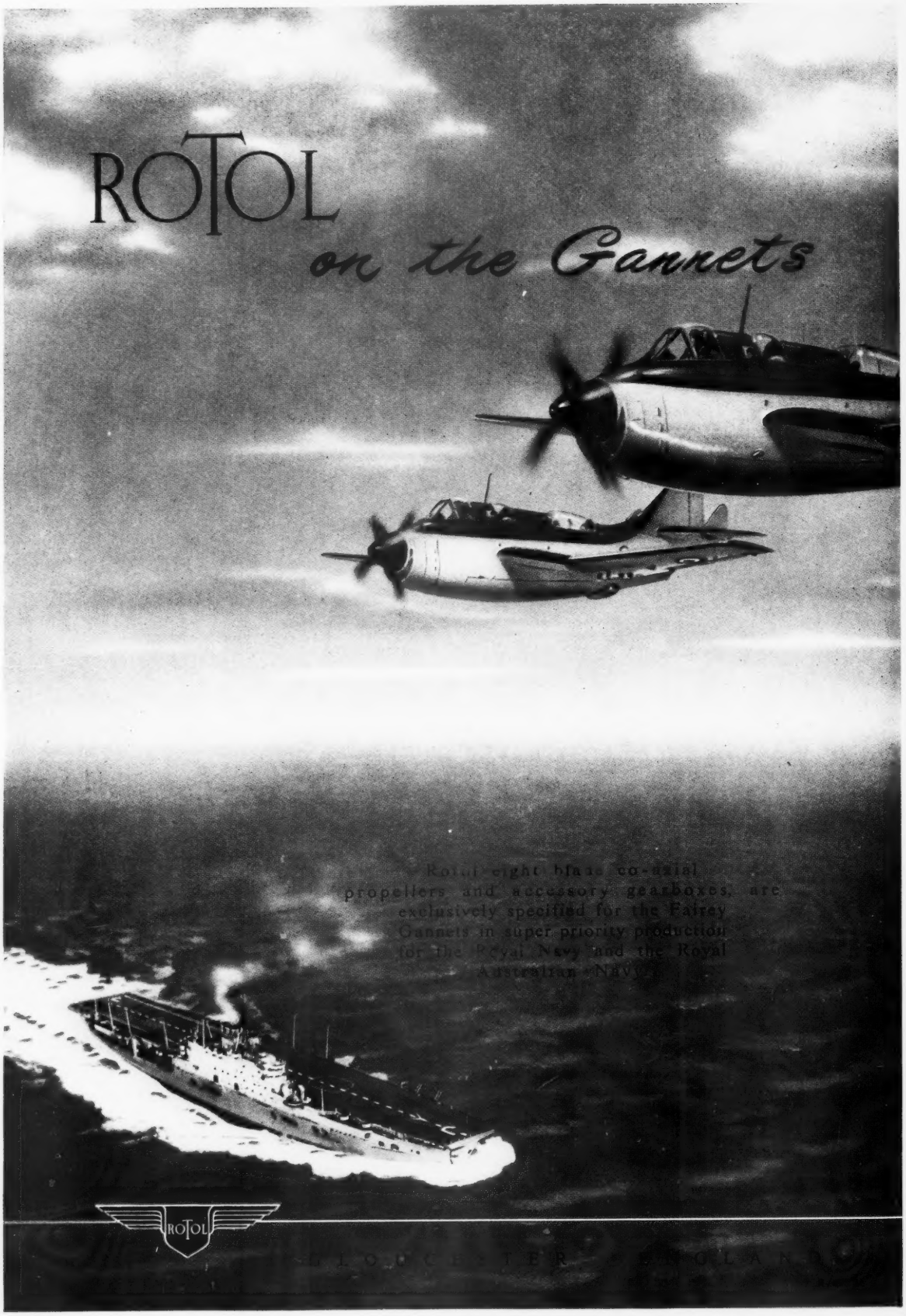
LMAS/PPPS/11



WITHIN five years of the Wright Brothers' first flight, Robert Blackburn designed and built his own aircraft which he flew in 1909. This machine was the forerunner of a long line of Blackburn aeroplanes, including the 1912 Monoplane, which is the oldest British aircraft flying today.

THE latest Blackburn product is the "Beverley" Transport, in production for the Royal Air Force. One propeller of this great freighter weighs more than the original aeroplane of forty-five years ago.

Blackburn and General Aircraft Limited, Brough, E. Yorks.


ROTOL
on the Gannets
Rotol eight blade co-axial propellers and accessory gearboxes, are exclusively specified for the Fairey Gannets in super priority production for the Royal Navy and the Royal Australian Navy.
ROTOL
GLOUCESTER

AGAIN DOUGLAS WINS A GREAT PERFORMANCE RACE!

DC-6A TAKES FIRST PRIZE IN TRANSPORT DIVISION IN INTERNATIONAL RACE FROM LONDON TO CHRISTCHURCH

Fully loaded with 64 passengers, 12 crew and a heavy cargo, a KLM Douglas Liftmaster (DC-6A) recently flew 13,100 miles from London to Christchurch, New Zealand, in 47 hours, 38 minutes actual flying time.

This superb performance easily won first place in the transport division for the giant Douglas DC-6A under a handicap formula which rewards the efficiency of transport aircraft operating long distances — with emphasis on low overall cost per ton-mile of payload.

The Christchurch race was the first such test of efficiency since the MacRobertson Trophy race in 1934. Here, too, the handicap section was won by a KLM Douglas airplane—the sturdy DC-2.

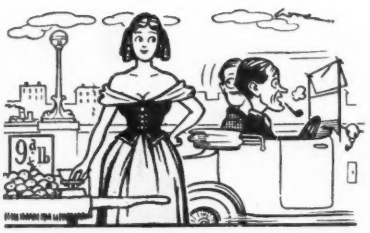
Building planes that can be produced in quantity to fly *farther and faster with a bigger payload* is a basic concept at Douglas.

Depend on DOUGLAS

First in Aviation

Sweet Nell of Old Vauxhall

BY BERNARD HOLLOWOOD



OUR interest in Petroleum flared up again with dramatic suddenness when we were told that part of the premises now occupied by the Technical Sales Department of *Esso* at Vauxhall was once the bower of " pretty, witty Nell " Gwyn of Old Drury. We are always looking for romance behind the prosaic, scientific façade of modern industry.

A bitterly cold day it was for our visit, "unseasonable" was, as usual, the description they used. A strong-to-gale force wind was whipping the Thames into a dirty foam-bath and sweeping the Albert Embankment clear of pedestrians, but we regarded it as a good omen when we encountered an orange-seller with his barrow. In mien and appeal he bore not the slightest resemblance to our heroine, and his prices were pretty stiff. But all the same. . . .

The Technical Sales team of the *Esso* establishment at Vauxhall are all eyes and ears. Their chief job is to help the aircraft industry—and incidentally *Esso* —by keeping abreast or wherever possible slightly in front of new developments in aeronautical design and engineering. The ears and eyes are cantilevered sufficiently to make this possible.

Like men and other animal species aircraft advance towards functional perfection through a process of natural selection. Models unable to adapt themselves swiftly enough to changing economic and climatic conditions become extinct, and the rest struggle on, trimming their feathers and wings to meet the needs of the moment.

But there is a difference. It takes man millions of years to make any significant change in the design of his skeletal frame, to alter the salinity of his blood-stream, to discard a useless rudimentary tail or to develop an effective resistance to the common cold. In the aircraft industry æons become years and centuries minutes: designs become old-fashioned even before they are in production, almost before they leave the drawing-board. Alpha, beta, gamma, delta, scimitar. . . .

"Alpha . . . beta . . . gamma . . . delta . . . scimitar.

And every modification in formal design calls for adjustments in the life-blood of modern aircraft—their fluid constituents, their fuel and lubricants.

No, that is not quite right. The aircraft designers do not normally evolve new structures and *hope* that fluids to match will be available: their new patterns in metal are devised with specific fuels, oils and greases in mind. They work hand in glove with the experts who design aircraft fluids; and the people who keep the two sets of designers in touch and in harmony are the Technical Sales Representatives.

" Diplomats . . . at every level . . ."

The T.S.R.s of *Esso* are engineers by training and experience, diplomats by inclination. They are in friendly personal contact with responsible people at every level of the aircraft industry, and they work in close association with chief engineers and designers, with leading experimental or project engineers. They are often " in " on a new design as soon as it is hatched, for with their unequalled experience and know-how they can usually point out possible snags long before they become apparent and costly; and at all times, of course, they are anxious to ensure that *Esso* fuels and lubricants are used with maximum efficiency and maximum advantage to the operators.

Sometimes a new design calls for an entirely new fuel or lubricant. Then, the T.S.R.s hare for Vauxhall to consult with their colleagues of the labyrinthine laboratories, and to launch new schemes of research and experiment. . . .

The labs at Vauxhall proved so much Greek to the itinerant landscapers in oils, and the day was such that we remained only for a few seconds in the Cold Chambers where airframe accessories and their lubricants were being tested at temperatures usually encountered only at 30,000 ft. during one of Mr. Buchan's cold spells.

"30,000 feet . . . Cold Spell"

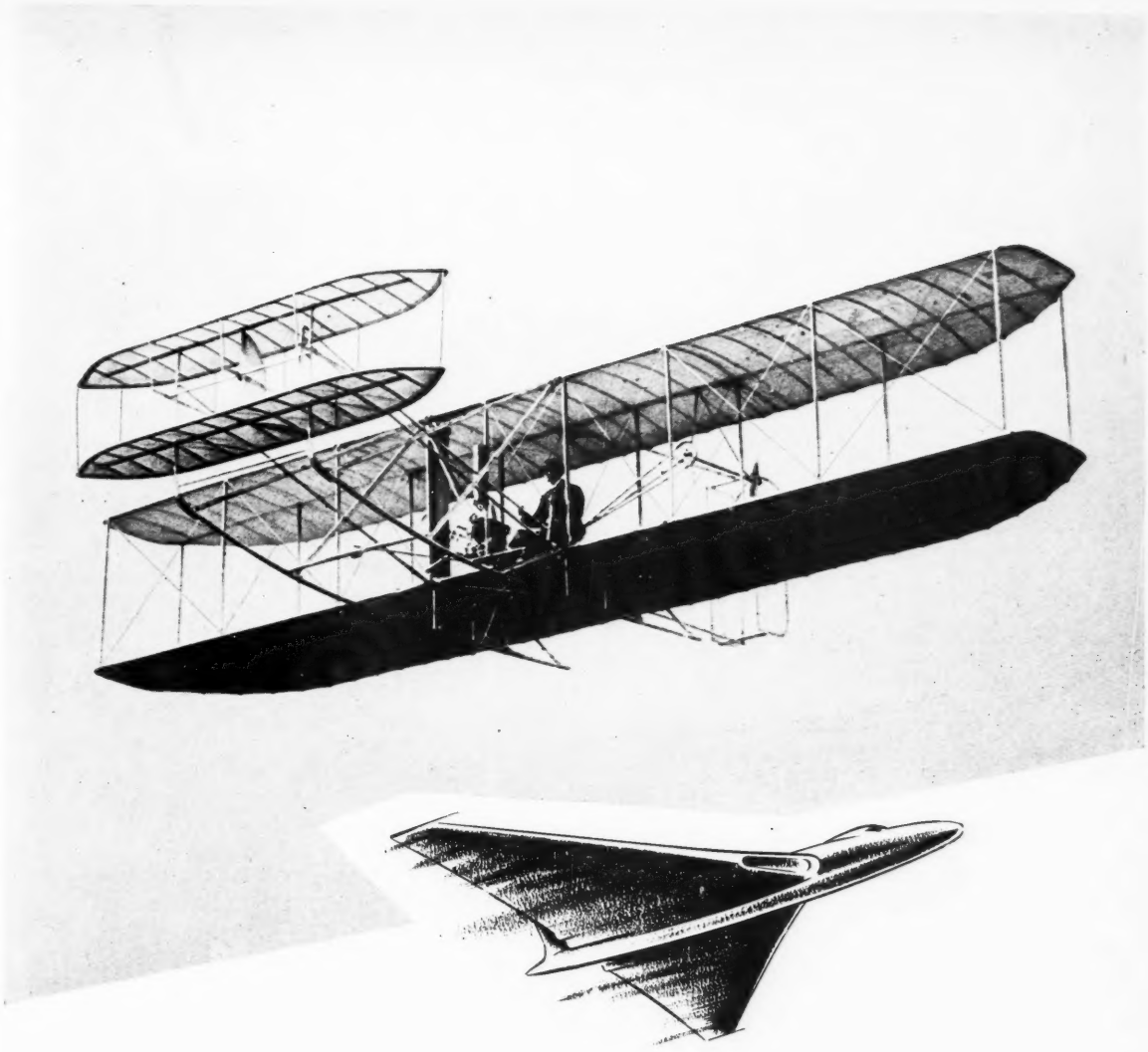
We asked about Nell, but nobody seemed interested and no scraps of saucy gossip came our way. The eyes and ears of the experts of the Technical Sales Department could, in fact, offer no advice other than the simple reminder (with which we were already perfectly familiar) that —

It pays to say

Esso

FOR ALL PETROLEUM PRODUCTS

ESSO PETROLEUM COMPANY, LIMITED, 36 QUEEN ANNE'S GATE, LONDON, S.W.1



Pioneering Still...

Rotax has served the British aircraft industry throughout its eventful progress—from the early beginnings to the present supersonic age.
The Wright Brothers' pioneering spirit of 50 years ago is very much alive in the aircraft industry today. We look forward with confidence to further discovery and development in the air—served, as in the past by Rotax . . .

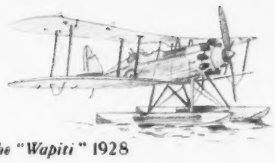
Complete Electrical Systems for Aircraft

ROTAX

ROTAX LIMITED, WILLESDEN JUNCTION, LONDON, N.W.10.
LUCAS-ROTAX (AUSTRALIA) PTY. LTD., MELBOURNE. N.3, AUSTRALIA.
LUCAS-ROTAX LTD. SCARBOROUGH, ONTARIO, CANADA.

Sperry weather
ILS

The "Intercepter Fighter" 1927

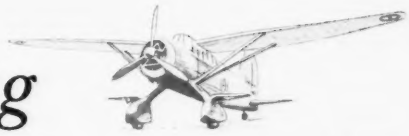


The "Wapiti" 1928

The "Wessex" 1929

The "Westbury" 1925

Pioneering since 1916



The "Lysander" 1935

Persistent pioneering in British aviation for nearly 40 years has placed this Company in the forefront in two major respects.

The Westland "Wyvern" the Royal Navy's first turbo-prop strike-fighter now serving at Squadron strength, represents the successful design experience arising from long association with service requirements and from courageous tackling of original technical problems.

Westlands private enterprise pioneering in the "rotary winged" field has resulted in the Company's supplying by far the largest number of Helicopters in Europe.

Everywhere S.51 commercial and Dragonfly helicopters and also the Westland S.55 10/12 seater helicopters are seen fulfilling many duties.

No other firm in Britain has rendered any service comparable to this, and Westlands background in helicopter design, manufacture, flight experience and research is without equal in Britain today.

The "Walrus" 1920

The "C.L.20. Autogiro" 1936

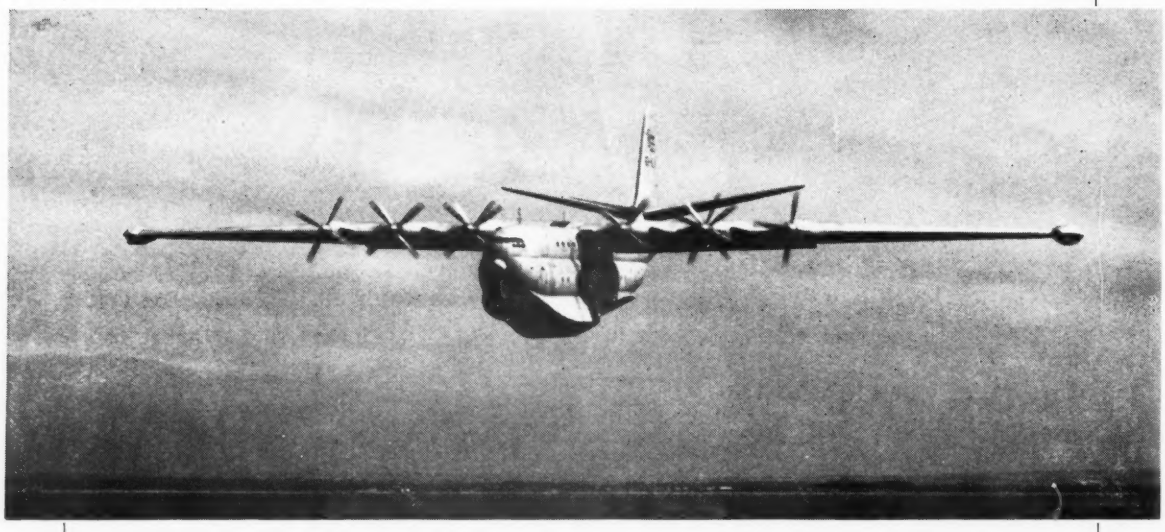
The "Weasel" 1918

The "Whirlwind" 1938

WESTLAND AIRCRAFT LTD.

YEOVIL ENGLAND

For ***economic*** *long-haul transport.....*
.....the **PRINCESS**



For ***economic*** *short-haul work.....*
.....the **SKEETER**

* NOTE: *NEITHER REQUIRES CONCRETE RUNWAYS*

SAUNDERS ROE LTD

HEAD OFFICE: OSBORNE EAST COWES ISLE OF WIGHT

SHELL

salutes the

aircraft industry

and mentions with pride that from the first flight across the English Channel to the latest jet records, SHELL fuels and lubricating oils have ALWAYS risen to the occasion.

1909 First flight across the English Channel by Louis Blériot.

1912 First winner of the aerial Derby — T.O.M. Sopwith.

1913 First winner of the Schneider Trophy — Maurice Prévost.

1919 First non-stop Transatlantic Flight — West to East — Sir John Alcock, Sir Arthur W. Brown.

1928 First solo flight — England to Australia, S/Ldr. Bert Hinkler.

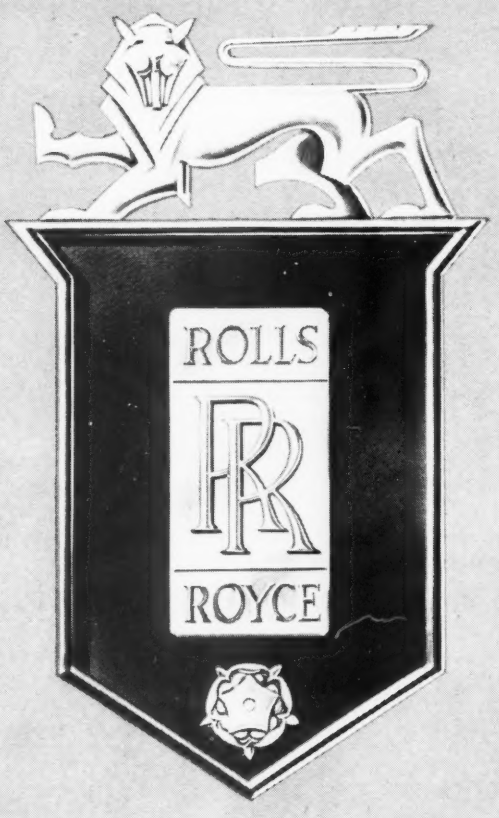
1930 First solo flight by a woman from England to Australia — Miss Amy Johnson.

1932 First solo Transatlantic Flight — East to West — J. A. Mollison

1953 Lt.-Com. "Mike" Lithgow used Shell Aviation Turbine Fuel to push the air-speed record even higher.

You can be sure of SHELL

SHELL



ROLLS-ROYCE

Aero

ENGINES

FOR SPEED AND RELIABILITY

ROLLS - ROYCE LIMITED · DERBY · ENGLAND

PU

T

V

Journal of

THE ROYAL AERONAUTICAL SOCIETY

WITH WHICH IS INCORPORATED THE INSTITUTION OF AERONAUTICAL ENGINEERS

PUBLISHED MONTHLY AT

4 HAMILTON PLACE, LONDON, W.1

Telephone: Grosvenor 3515-9 *Telegrams*: Didaskalos, Audley, London

SUBSCRIPTIONS: £6 6S. 0D. PER ANNUM, POST FREE. SINGLE COPIES: 10S. 6D., POST FREE.

VOLUME 57 DECEMBER 1953 NUMBER 516

CONTENTS

PAGE

Notices LXVII

Christmas 1953—Aircraft Movement at Airports, Lecture at Institution of Civil Engineers—Graduates' and Students' Section: 17th December Arrangements and Visit to Imperial College, 26th January—Elections—Diary of Lectures—Subscriptions.

The Wright Brothers and The Royal Aeronautical Society J. LAURENCE PRITCHARD 739

Technical Notes 819

Definition of Specific Impulse—S. W. GREENWOOD. Some Measurements of Leading Edge Separation Bubbles on a 10 per cent. thick Symmetrical Aerofoil—J. BLACK and R. D. HUNT. Optimum Conditions for the Operation of Airline Aircraft—J. M. STEPHENSON—A. H. STRATFORD.

The Library 825

REVIEWS:—The Papers of Wilbur and Orville Wright: A Preview—History of Strength of Materials—A History of Flying—Test Pilot—The Spirit of St. Louis—Comet Highway—Boldness be my Friend—Fifty Years of Flight—Tumult in the Clouds—Aircraft Year Book 1952—Aircraft Engines of the World, 1953—Arctic Solitudes—British Standards for Workshop Practice.

ADDITIONS TO THE LIBRARY REPORTS

Index to Volume LVII January-December 1953

NOTE: *The photograph on the cover is of a bust in bronze signed "L. Carvin Hangar de Pont-long 10-2-09," which was presented to the Society by the late Griffith Brewer.*

All communications for publication in, and advertisements for, the Journal should be addressed to the Editor, Joan Bradbrooke, A.R.Ae.S.; all communications on general matters affecting the Society should be addressed to the Secretary, A. M. Ballantyne, T.D., B.Sc., Ph.D., A.F.R.Ae.S.

None of the papers or paragraphs must be taken as expressing the opinion of the Council of the Royal Aeronautical Society unless stated otherwise.

PRINTED BY THE LEWES PRESS (WIGHTMAN & CO. LTD.), LEWES, SUSSEX, ENGLAND, AND PUBLISHED BY THE ROYAL AERONAUTICAL SOCIETY, 4 HAMILTON PLACE, LONDON, W.1, ENGLAND.

The Royal Aeronautical Society

(Founded 1866)

PATRON
HER MAJESTY THE QUEEN

COUNCIL 1953—1954

PRESIDENT

SIR WILLIAM FARREN, C.B., M.B.E., M.A., F.R.S. (*Fellow*)

PAST PRESIDENTS

G. H. DOWTY, F.I.A.S. (*Fellow*)
MAJOR F. B. HALFORD, C.B.E. (*Fellow*)
MAJOR G. P. BULMAN, C.B.E., B.Sc. (*Fellow*)

VICE-PRESIDENTS

SIR SYDNEY CAMM, C.B.E. (*Fellow*)
G. R. EDWARDS, C.B.E., B.Sc. (*Fellow*)
P. G. MASEFIELD, M.A., F.I.A.S. (*Fellow*)

ORDINARY MEMBERS

AIR COMMODORE F. R. BANKS, C.B., O.B.E. (*Fellow*)
PROFESSOR A. D. BAXTER, M.Eng. (*Fellow*)
SIR JOHN S. BUCHANAN, C.B.E. (*Fellow*)
PROFESSOR A. R. COLLAR, M.A., D.Sc., A.F.I.A.S. (*Fellow*)
E. B. DOVE (*Associate*)
A. G. ELLIOTT, C.B.E. (*Fellow*)
SIR HARRY M. GARNER, K.B.E., C.B., M.A. (*Fellow*)
A. A. HALL, M.A., F.R.S. (*Fellow*)
N. J. HANCOCK (*Associate Fellow*)
E. T. JONES, C.B., O.B.E., M.Eng. (*Fellow*)
E. S. MOULT, Ph.D., B.Sc. (*Fellow*)
W. E. W. PETTER, C.B.E., B.A. (*Fellow*)
CAPT. J. L. PRITCHARD, C.B.E., Hon. F.I.A.S. (*Hon. Fellow*)
N. E. ROWE, C.B.E., B.Sc., D.I.C., A.F.I.A.S. (*Fellow*)
J. G. ROXBURGH (*Associate Fellow*)
B. S. SHENSTONE, M.A.Sc., A.F.I.A.S. (*Fellow*)
W. TYE, O.B.E., B.Sc. (*Fellow*)
C. F. UWINS, O.B.E., A.F.C. (*Fellow*)

OFFICERS

Honorary Treasurer: C. F. UWINS, O.B.E., A.F.C. (*Fellow*)
Solicitor: L. A. WINGFIELD, M.C., D.F.C. (*Associate*)
Secretary: A. M. BALLANTYNE, T.D., Ph.D., B.Sc. (*Associate Fellow*)

NOTICES

Christmas 1953

The President, Sir William Farren, the Council and the Staff of the Society wish all members, at home and overseas, a Very Happy Christmas.

Christmas Holidays

The Library and Offices of the Society will be closed from 5 p.m. on Thursday 24th December until 9 a.m. on Tuesday 29th December.

Institution of Civil Engineers—Lecture

A Lecture on "The Control of Aircraft Movement at Airports" will be given at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1, by Mr. Clifford Hayes and Mr. E. J. Dickie, on Tuesday 12th January 1954, at 5.30 p.m.

Members wishing to attend should apply to the Secretary of the Institution of Civil Engineers for tickets.

Graduates' and Students' Section—17th December

The film "Powered Flight—Story of the Century" which has been specially made to commemorate the 50th anniversary of the Wright Brothers first powered flight will be shown at a joint meeting of the Section and the London Branch of the Institute of Petroleum on 17th December at 6.45 p.m. at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, W.1.

Admission to members of the Section and their guests is by ticket only. Applications, enclosing a stamped addressed envelope, should be sent to: J. D. Arthur, Waysmeet, Epsom Road, Ewell, Surrey.

Dinner:—The film show will be followed by an informal dinner at 8.30 p.m. at the nearby Bolivar Restaurant in Chandos Street. Cost 11/- per person. Names for this dinner will be taken at the film show, but, to assist the organisers, members are asked to state whether they wish to attend the dinner when applying for film show tickets.

Graduates' and Students' Section—Imperial College

A visit to the Imperial College of Science and Technology has been arranged for Wednesday 27th January 1954, at 6.30 p.m. Visitors will be able to see the wind tunnels, structural test rigs and so on. Supper will be available at the College at moderate charges. Applications, stating whether dining or not, should be sent to the Hon. Visits Secretary, D. W. J. Richards, 18 Geneva Road, Kingston-on-Thames, Surrey.

Elections

The following is a list of new members and transfers of membership of the Society:—

Associate Fellows

Lewis Robert Ambrose
Henry Gordon Anthony (*from Graduate*)
Derrick William Brown
Jack Toynbee Burr (*from Graduate*)
Reginald Ernest Collins (*from Associate*)
Norman George Noel Davis
Peter John Detmold (*from Associate*)
William Sidney John Drew (*from Associate*)
Laurence Sydney Edwards (*from Associate*)
Robert Clears Fordham
Gerald William Kitto Frayling
Maurice Hugh Charles Gordon (*from Associate*)
Ernest Noel Grantham (*from Graduate*)
Reginald Irvan Gray
Thomas George Guppy (*from Associate*)
James Nuttall Haworth
John Anthony Hay (*from Graduate*)
George Frederick Heginbotham
David Kenneth Henderson
John Bertram Holliday (*from Graduate*)
Robert Noel Hollock
George John Houghton (*from Graduate*)
Arthur Bertram Roy Hudson (*from Associate*)
George Donald Huxtable
Leonard Raymond I'Anson
Victor Albert Jarvis
Philip Jarvis Johnson (*from Graduate*)
Edwin Jones (*from Graduate*)
Thomas Vincent Lawson
Gordon Walter Little (*from Graduate*)
Colin Vernon Olver (*from Associate*)
Donald Parker
Albert Charles Parks (*from Associate*)
Frederick Arthur Parsons (*from Graduate*)
John Charles Henry Peaker (*from Graduate*)
Robert Colin Pearson
Arthur John Pegg
Ernest Roe Pemberton
Reginald Herbert Havelock Pelling (*from Associate*)
Joseph Harbit Pool
John Thomas Pratt (*from Graduate*)
Alexander Walpole Prickett
George Campbell Ross
John Gordon Roxburgh (*from Graduate*)
Stanley Russell Rudge
Howard Roderick Saunders
Robert Wolsey Sugg
Richard Tourret (*from Graduate*)
Stanley Ralph Tyler (*from Graduate*)
Norman Edward Percival Waldren (*from Graduate*)
George Ernest Walker
Roy Westbury
Frederick Francis Wicks
John Cecil Wimpenny (*from Graduate*)
Harry Zeffert.

Associates

Godfrey Lovell Auty
Philip Joseph Barker
Harry Simon Beadle
John Charles William Beadle (*from Student*)
Albert Charles Cleves
John Crampton
Leonard Victor William Dickison
William Little Farish (*from Graduate*)
Albert Edward Walter Field
Stewart John Hill
Christopher Frederick Kidd
Alfred Brian Hugo Lamplugh (*from Companion*)
Mancel Clements John Major
Anthony Alden Barlow Naylor
Reginald William George Ranner
Joseph Harold Richardson
Trevor Maxwell Smith
Edward Alan Tennant
Douglas Peter Thorne
Frank Michel Tippetts

Graduates

Kenneth Walter Batten (*from Student*)
Derek William Brown (*from Student*)
John Woodbury Bugler (*from Student*)
Alan Ferguson Chalmers
Arthur Robert Chandler (*from Student*)
Michael Frederick Collins
Roger Sidney Dabbs
James Robert Dixon
Kenneth George Draper
Peter John Farmer (*from Student*)
George Kasin Ferris (*from Student*)
Alan Gettings
David John Greedy
Roy Hawkins
Michael James Henwood (*from Student*)
Michael Alexander Hollingsworth
Peter Frederick Jowitt
Paul Gerald Pearce
Ronald William Prizeman (*from Student*)
Leonard James Rogers (*from Student*)
Geoffrey Edward Rogerson
James Cleave Simmons
Derek William Stowe
John Edward Talbot (*from Student*)
Ronald Ian Vaughan
Martin James Wagrel (*from Student*)

Students

Bertrand Brownlow
William Ralph Bishop Bryder
Michael Thompson Darwood
Francis Alfred Dewar
James Erwin
Ian James Ford
Michael Reeve Fountain
Stanley James Fincham
Anthony Gibbs
Gerald Derek Horne
S. Chenna Keshu
Brian Michael Lempriere
Alan Gregor Lowe
Henry Claude McKay
Brian Graeme Mercer
Ronald George Mitchell
William James Milne Parnell
Royston Kenneth Penny
John Lester Rudkin
Lexmipuram Srinivasachar Srinath
Philip Valentine Walker
Michael Leslie Wall

Companion

Henry Ernest Marking

Diary

LONDON

December 15th
SECTION LECTURE. Jet-Driven High-Speed Wind Tunnels. D. L. Ellis, F.R.Ae.S., 4 Hamilton Place, W.1. 7 p.m.

December 17th
GRADUATES' AND STUDENTS' SECTION. Joint Meeting with the Institute of Petroleum. Film Show including film Commemorating the Fiftieth Anniversary of Powered Flight. Manson House, Portland Place, W.1. 6.45 p.m.

January 7th 1954
LECTURE TO YOUNG PEOPLE. The Fun of Finding Out in Flying. Sir Leonard Bairstow, C.B.E., F.R.S., Hon.F.R.Ae.S. At the Institution of Mechanical Engineers, Storey's Gate, S.W.1. 3 p.m.

January 21st
MAIN LECTURE AT THE SOUTHAMPTON BRANCH: First Mitchell Memorial Lecture. J. Smith, C.B.E. Institute of Education, University of Southampton. 7 p.m.

January 26th
SECTION LECTURE. X-Ray Metallography. Dr. G. L. J. Bailey. 4 Hamilton Place, W.1. 7 p.m.

BRANCHES

December 10th
Belfast.—MAIN SOCIETY LECTURE. Flight Simulators. C. B. Ringham and Dr. A. E. Cutler. Whitla Hall, Methodist College, Belfast. 7 p.m.

December 11th
Preston.—Dinner Dance in Celebration of the Wright Brothers' Golden Jubilee. Imperial Hotel, Blackpool.

December 14th
Halton.—Junior Members' Night. Branch Hut, R.A.F. Station, Halton. 6.45 p.m.

December 17th
Bristol.—Celebration of the 50th Anniversary of Powered Flight. Conference Room, Filton House, Bristol Aeroplane Co. 6 p.m.
Chester.—Dinner and Film Show to Celebrate the 50th Anniversary of Powered Flight. Blossoms Hotel, Chester. 7.30 p.m.
Coventry.—Social Evening and Films to Commemorate the 50th Anniversary of Powered Flight. Wine Lodge, Coventry. 7.30 p.m.
Isle of Wight.—Annual General Meeting, followed by 50th Anniversary of Powered Flight Film. The Club House, Saunders-Roe, Church Path, E. Cowes. 6.30 p.m.

December 18th
Birmingham.—Film. 50 Years of Powered Flight. Birmingham Chamber of Commerce. 7.30 p.m.
Weybridge.—Annual Dance. St. George's Hill Tennis Club.

December 21st
Brough.—50th Anniversary of Powered Flight Commemoration Dinner. Guildhall, Hull. 7.15 p.m.

January 4th 1954
Bristol.—A Review of Developments in Aircraft Equipment. G. H. Dowty. Conference Room, Filton House, Bristol Aeroplane Co. Ltd. 6 p.m.
Derby.—Annual General Meeting and Branch Competition Papers. Rolls-Royce Welfare Hall.

January 6th
Belfast.—Second Joint Meeting with Queens University, Belfast, Film Society. Films include: (1) R.Ae.S. Film Commemorating 50 Years of Powered Flight; (2) Travel Royal. Whitla Hall, Methodist College, Belfast. 7 p.m.
Brough.—New Developments in Aircraft Production Engineering. Professor J. V. Connolly. Electricity Buildings, Hull. 7.30 p.m.
Chester.—Guided Weapons. D. J. Lyons. Grosvenor Hotel, Chester. 7.30 p.m.

January 6th
Luton.—Wilbur Wright Centenary Film. George Hotel. 7.30 p.m.
Southampton.—Annual General Meeting, followed by Films. Institute of Education, The University. 7 p.m.

January 11th
Birmingham.—Joint Meeting with the Institute of Rubber. James Watt Institute, Great Charles Street, Birmingham. 7.30 p.m.
Halton.—The Propeller Gas Turbine Engine. A. C. Clinton. Branch Hut, R.A.F. Station, Halton. 6.45 p.m.

January 13th
Hatfield.—Stability and Control in Aircraft Design. J. C. Wimpenny. de Havilland Restaurant, Hatfield. 6.15 p.m.
Weybridge.—Sailplane Design. K. G. Wilkinson. Vickers-Armstrongs Ltd., Weybridge Works. 6 p.m.

January 14th
Isle of Wight.—Large Press Forgings. E. T. Stewart-Jones. Club House, Saunders-Roe Sports and Social Club, Church Path, E. Cowes. 6.30 p.m.

January 15th
Glasgow.—The Pilot's Point of View. Officers of the University Air Squadron. Royal Technical College. 7.30 p.m.

January 18th
Halton.—Branch Night. Branch Hut, R.A.F. Station, Halton. 6.45 p.m.

January 19th
Belfast.—Flight Testing Problems. D. N. Scard. Kerr Room, Kensington Hotel, Belfast. 7 p.m.

January 20th
Bristol.—Design Problems of the Transport Helicopter. R. Hafner. Conference Room, Bristol Aero. Co. 6 p.m.
Coventry.—Recent Developments in Gliding. A. H. Yates. Wine Lodge, Coventry. 7.30 p.m.
Leicester.—Annual General Meeting and Film Show. 1 Newarke Street, Leicester. 7.15 p.m.
Manchester.—Lecture. Reynolds Hall, College of Technology. 7.30 p.m.
Preston.—Stability and Control of Delta Wing Aircraft. Wg. Cdr. R. J. Falk. Queen's Hotel, Lytham. 7.30 p.m.

January 21st
Southampton.—MAIN LECTURE. First Mitchell Memorial Lecture. J. Smith. Institute of Education, The University. 7 p.m.

January 25th
Halton.—Junior Members' Night. Branch Hut, R.A.F. Station, Halton. 6.45 p.m.

January 27th
Weybridge.—Space Flight. J. Humphries. Vickers-Armstrongs Ltd., Weybridge Works. 6 p.m.

ANNUAL SUBSCRIPTIONS

Members are reminded that their annual subscriptions become due on 1st January 1954. The rates are:—

	HOME £ s. d.	ABROAD £ s. d.
Fellows	5 5 0	4 4 0
Associate Fellows	4 4 0	3 3 0
*Associates	3 3 0	3 3 0
Graduates (aged under 26)	2 2 0	2 2 0
Graduates (aged 26 and over)	2 12 6	2 12 6
Students (aged under 21)	1 1 0	1 1 0
Students (aged 21 and over)	1 11 6	1 11 6
Companions	3 3 0	3 3 0
Founder Members	2 2 0	2 2 0

* Any Associate elected before 1st October 1947 may, if he wishes, elect not to receive the JOURNAL, and in this case his subscription will be reduced by £1 1s. 0d. to £2 2s. 0d.

It will avoid delay and confusion if members, when sending remittances for subscriptions, will state their names clearly and give their addresses and grades of membership. Remittances should be made payable to the Royal Aeronautical Society.

Journal of The Royal Aeronautical Society

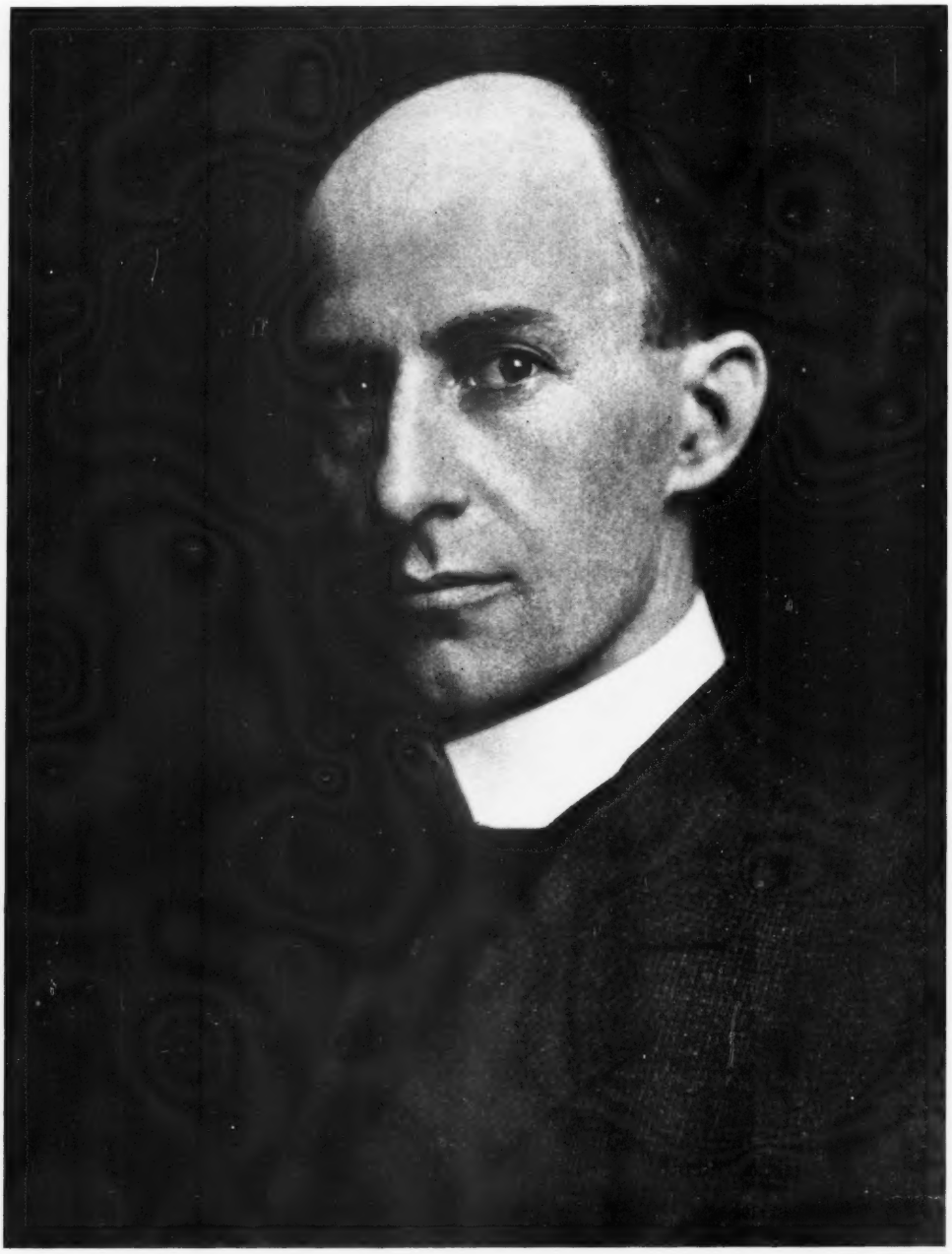
WITH WHICH IS INCORPORATED THE INSTITUTION OF AERONAUTICAL ENGINEERS

VOLUME 57 DECEMBER 1953 NUMBER 516

"MORE than forty years ago, at a time when flying was little thought of in the world, some of the citizens of England banded themselves together to form this Society, and through all the years which have followed, during times when any talk about flying was considered ridiculous, and all the people who thought about it were laughed at, this Society met every season to consider the subject of flying, to report the work which its individual members had been doing, to publish these papers which we read, and to spread them throughout the world for the benefit of others".

Wilbur Wright.

On being presented with the Gold Medal of the Society 3rd May 1909.



Wilbur Wright

Orville Wright

THE WRIGHT BROTHERS

and the

ROYAL AERONAUTICAL SOCIETY

A Survey and Tribute

by

J. LAURENCE PRITCHARD, C.B.E., Hon.F.R.Ae.S., Hon.F.I.A.S

' Let us now praise famous men'—
Men of little showing—
For their work continueth,
And their work continueth,
Broad and deep continueth,
Greater than their knowing!
Rudyard Kipling.

IT IS OF CARDINAL IMPORTANCE that the facts of aeronautical history should be placed on record.

The stirring stories of these tremendous first fifty flying years must be told where and when and how they can, but should be told quickly before the mists of time and memory lose them for ever.

Here is set down the story of the unprecedented achievement of the Wright Brothers, their impacts on, and relationships with, those members of the one-time Aeronautical Society of Great Britain who knew them and were aware of the reality of their genius. It is a story of some importance and one which it is fitting should be on record in the Society's own publication, for all to read who may. It is told by the brothers themselves, and by members of the Society.

This is the story of the vindication of the claim of the Wright Brothers to be the first men in the world to fly; and the story of the evidence for the triumphant acknowledgment of that claim provided by a President of the Royal Aeronautical Society and other leading members of the Society.

Some of the material for the story is to be found in the volumes of the JOURNAL of the Society and in letters written by the brothers and members, letters now in the Society's possession. Extracts from many of these letters are now published for the first time.

The sources from which this paper has been written are given on page 814.

I gladly acknowledge the help of the Council and of the staff of the Society. I owe a particular debt of gratitude to Lieutenant-Colonel A. Ogilvie, a *Fellow* of the Society of long standing and a close personal friend of both Wilbur and Orville Wright, for his kindness and patience in reading this paper and for his many suggestions and corrections which have been incorporated in the paper.

The Years Before: 1896 - 1902

"I would be a bird, and straight on wings arise,
And carry purpose up to the ends of the air".

Robert Bridges.

Man has ever wanted to grow wings before his time, so it is strange that he did not learn the art of gliding many centuries ago, when the knowledge he required was within his intellectual grasp and all that was wanted was its practical application.

In the fifty years preceding the first heavier-than-air powered flight in 1903, there were many who were conscious that the growth of theoretical and applied science was inevitably shortening the time that remained before flying would be no longer a dream of future achievement.

In Great Britain, the United States, Europe and Australia, aeronautical pioneers, whose achievements and failures are now engraved on the nameplates of history, were theorising and experimenting. The Aeronautical Society of Great Britain had been founded in 1866, and two years later had held, at the Crystal Palace, near London, the first Aeronautical Exhibition in the world at which Stringfellow's famous steam-engine-driven model aeroplane was demonstrated. On its first Council the Society could count the names of leading scientists and engineers, one of whom, F. H. Wenham, laid down in the very first lecture read before the members of the Society on June 27 1866, "The Laws by which Heavy Bodies impelled through the Air are sustained."

It was of Wenham that Wilbur Wright said: "Mr. Wenham we regard as one of the ablest and most useful men who have labored in the cause of flight."

Another member of the Council, a Fellow of the Royal Society, James Glaisher, held the world's altitude record of 37,000 feet, and had carried out many balloon ascensions, for the purpose of scientific investigation of atmospheric phenomena, on behalf of the British Association. Glaisher was a firm believer in heavier-than-air craft, as was the first President of the Society, that Duke of Argyll who had been President of the British Association in 1855 and the author of a famous work *The Reign of Law*, in which he declared the beliefs in heavier-than-air craft held by so many members of the newly formed Society, as well as by the majority of its first Council.

For over three-quarters of a century there has been an exchange of information on aeronautical matters between members of the Aeronautical Society of Great Britain and members of engineering and other bodies in the United States of America, an exchange for most of those years on an individual basis. In recent years the Society has done much to increase the rate of exchange in aeronautical matters.

In a letter dated February 3 1882, to F. W. Brearey, the first secretary of the Society, Octave Chanute*, then President of the American Society of Civil Engineers, and later a close friend of the Wright Brothers, wrote:

> "We are, in this country, aware of your long-continued experiments and efforts to promote a solution of the problem of aerial navigation, and know that it is through your influence that the subject has been cleared of much rubbish and placed upon a scientific and firm basis."

The first Gold Medals of the Aeronautical Society were awarded to Americans, Wilbur and Orville Wright in 1909, and Octave Chanute in 1910, and these were the only Gold Medals awarded to Americans until the award to Theodore von Kármán in 1952. Chanute, who had been a member of the Society for many years, carried out many gliding experiments, and corresponded widely with those, in various parts of the world, who were interested in aviation. He did much to encourage the Wright brothers in their early experiments. He wrote regularly to leading members of the Society, including Brearey, already noted; Major Baden-Powell, who became President; Patrick Alexander, to whose generosity the Society and early British aeronautical endeavour owed so much; to Alexander McCullum, whose articles on *The Navigation of the Air* in the *Glasgow Herald* in 1897 attracted wide attention; to Sidney Hollands, who worked with Hiram Maxim on his large machine; and to many others, giving them account of the experiments being carried out in the United States.

Baden-Powell, in particular, was a regular correspondent with experimenters in America. He wrote to M. N. Forney, editor of the *American Engineer and Railroad Journal* in which appeared Chanute's famous series of articles on Flying Machines; to S. P. Langley, the well-known secretary of the Smithsonian Institution in Washington, who had long experimented with powered model aircraft; to the Wright brothers and to many others. Baden-Powell, indeed, was one of the first men to impress upon members in his lectures and papers in the JOURNAL, the importance of the work the Wrights were doing. He was the second Englishman to go up in an aeroplane with Wilbur Wright as pilot.

Baden-Powell was an indefatigable experimenter, lecturer, and writer on aviation in all its aspects. He joined the Society in 1880, served on the Council for many years, and for seven years was its President. He also became President of the Kite Flying Association and in 1894 made the first man-lifting kite, making several ascents up to a hundred feet. Balloons, airships, kites, gliders, model aircraft, aeroplanes, all came alike to Baden-Powell. His energy was astonishing, his knowledge of what was happening in aeronautical endeavour encyclopædic, but his own experimental work too wide-spread and his technical knowledge too little for successful individual accomplishment.

In 1889 Otto Lilienthal, in Germany, published his book on *Bird Flight as the Basis of Aviation*, giving the results of his studies of the flight of birds. Two years later he made his first glider and for the next four years

* Chanute's first interest in aviation was aroused by F. H. Wenham, whom he met in 1874 when on a visit to England, and with whom he afterwards corresponded.

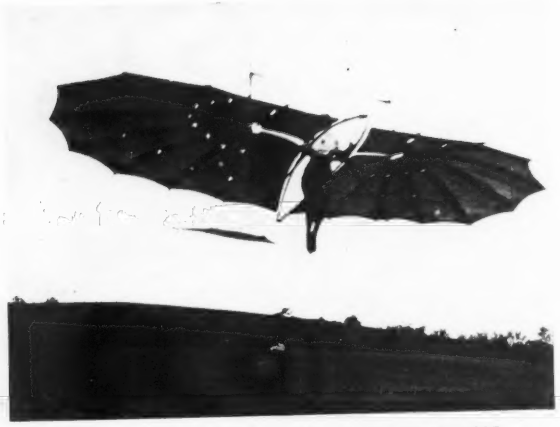


FIGURE 1. Percy Pilcher gliding in the Hawk, 1897.

FIGURE 2. Lilienthal's power-driven ornithopter, 1895.

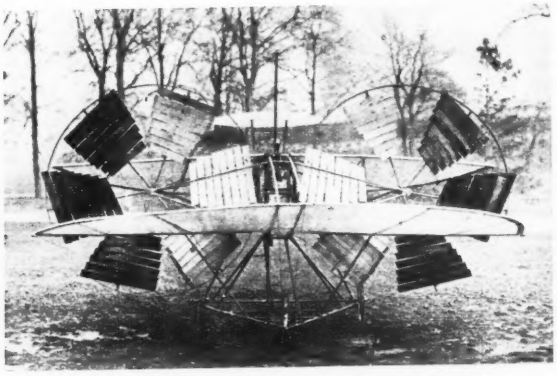


FIGURE 3. Moy and Shill's Aerial Steamer, 1875.

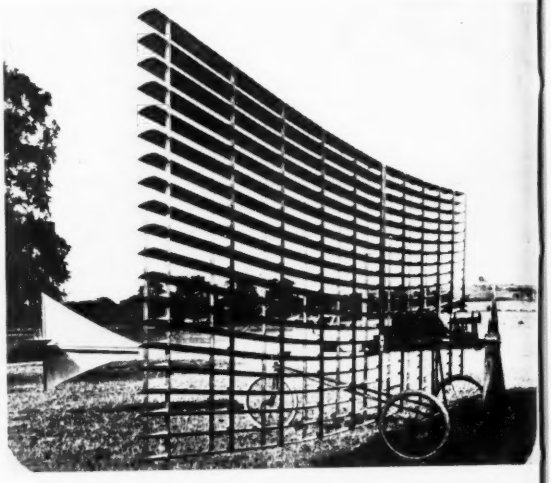


FIGURE 4. Phillips' " venetian blind " aeroplane, 1899.

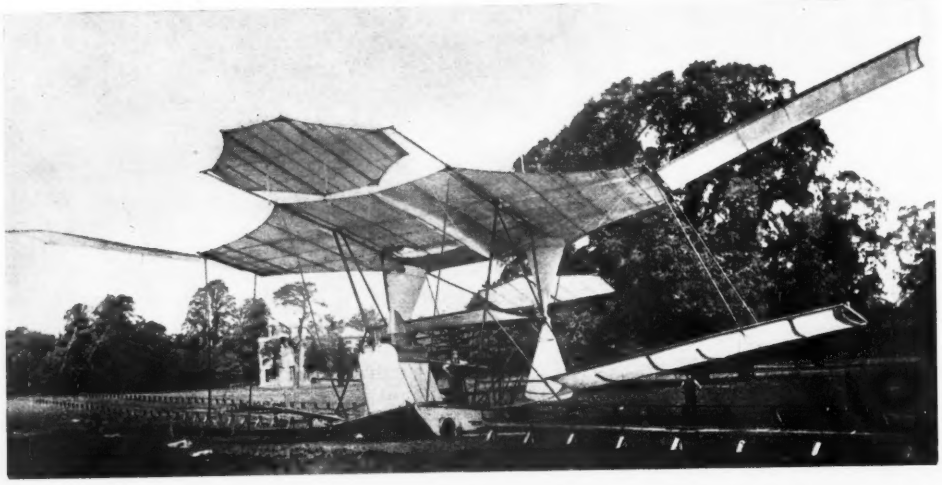


FIGURE 5. Maxim aeroplane at Baldwyn Park, 1891.

he made many gliding experiments and constructed various forms of gliders. He built an artificial hill outside Berlin, from which to glide, and in June 1895 was visited by Percy Pilcher (who was born the same year the Society was founded), an engineer who had been closely associated with Sir Hiram Maxim. Pilcher, who had been experimenting with his own type of glider, came back from his Berlin visit convinced that the conquest of the air was near.

But it was still ten years away.

Both men relied for the control of their gliders upon their own quickness of reaction and movement, the skill, indeed, of a tight rope walker in the air without the tight rope or the safety net. Both only partly understood the risks they were taking, so both practised for the sole purpose of becoming familiar with the starting and landing conditions and methods of control in the air by the movement of their own bodies, in order that they could fly "with comparative safety" to use Pilcher's own words. But one can never sit upon the centre of pressure with safety for long.

Both men planned to fit an engine into their latest glider, and both lost their lives before they could do so, through being unable to keep control of their gliders. Percy Pilcher was the first member of Council of the Society to lose his life in an air accident.

It is worth while interpolating here the comment of Wilbur Wright on Lilienthal, in his address to the Western Society of Engineers in September 1901, describing some of his own gliding flights.

> "It seemed to us that the main reason why the problem had remained so long unsolved was that no one had been able to obtain any adequate practice. We figured that Lilienthal in five years of time had spent only about five hours in actual gliding through the air. The wonder was not that he had done so little, but that he had accomplished so much. It would not be considered at all safe for a bicycle rider to attempt to ride through a crowded city street after only five hours practice, spread out in bits of ten seconds each over a period of five years; yet Lilienthal with this brief practice was remarkably successful in meeting the fluctuations and eddies of wind gusts. . . ."

In the early 1890's Hiram Maxim, another energetic member of the Society, well-known for the gun named after him, built his famous steam-engine-driven aeroplane weighing some 8,000 lb. Maxim decided to test it along special rails to ascertain the total lifting power before venturing on free flight.

The steam engine developed 360 h.p. and he was confident that at a speed of 45 m.p.h. the wings would lift 10,000 lb. He obtained the lift he expected, but the upper guard rails which had been designed to prevent free flight, failed to hold the machine down, and it crashed out of control.

Writing in the *North American Review* in October 1895, he said "the experiments have led me to believe that the flight of man is possible even with a steam engine and boiler. I would, however, advise the young engineers who may read this paper, if they wish to do something to advance the science of aviation, to turn their thoughts in the direction of the petroleum motor . . . I believe it is the petroleum motor that we must look to in the future as being the engine which will drive our flying machines."

Maxim spent over £20,000 on his experiments with no success from a flying point of view, though he showed that great weights could be lifted in the air with the power then available. Many of these early pioneers lost everything in their search for the secret of flying. Horatio Phillips, a member of the Society for many years, whose "venetian blind" machine and curved aerofoils are well-known, had to give up after spending close on £5,000 in the second half of the nineteenth century, when such a sum was a substantial fortune.

Thomas Moy, who for over twenty years continued to experiment, died in poverty, after spending over £4,000. The work and ideas of Moy, a competent engineer who became a member of the Society in 1870, are recorded in many pages of the Society's Annual Reports. In one of these Reports it was said of his machine that it was "the most determined attempt at solving the problem that has yet taken place." Octave Chanute, in *Progress in Flying Machines*, gives one of the fullest descriptions published of Moy's design.

The steam engine used was designed by Moy's partner Shill, and weighed with boiler 80 lb., developing 3 h.p. The aeroplane, fitted with a tricycle undercarriage, weighed 216 lb., a little less than 2 lb. per sq. ft. of surface. In between the fore and aft planes were two large "aerial wheels," which were expected to develop sufficient thrust to lift the machine into the air at a forward speed of 35 m.p.h. The maximum speed reached, however, was only 12 m.p.h., for the resistance of the structure had been very much underestimated.

E. P. Frost, for many years a member of Council and for a time President of the Society, spent large sums carrying out experiments near Cambridge in the last quarter of the nineteenth century, with a flapping wing machine, with beautifully made feathers of metal. He was a rich man, able to indulge in his hobby, but he did not get to the stage of making even controlled short hops, a failure he attributed to the lack of a light engine. As Frost tried to imitate the bird, so Major Moore, another member, tried to learn from the flying fox, with equal lack of success, though he fully persuaded himself, and half persuaded a few others, that he was on the right lines.

Lawrence Hargrave, elected a member of the Society in 1897, was born in England and emigrated to Australia in the year of the Society's birth. He carried out a long series of remarkable experiments between 1884 and 1909 which will always find a descriptive and honoured place in any history of aeronautics. He published his discoveries freely for any one to use.

Hargrave was the designer of the first rotary engine and, later, the box kite which made him famous and on which Santos Dumont made the first European flight in 1906. The Hargrave box kite, in fact, as early as 1894, had greater lift and stability than any other form of kite up to that time, and following experiments with it Hargrave was able to put forward sound suggestions

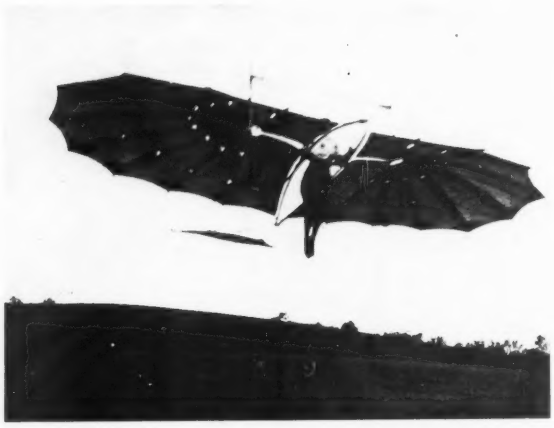


FIGURE 1. Percy Pilcher gliding in the Hawk, 1897.

FIGURE 2. Lilienthal's power-driven ornithopter, 1895.

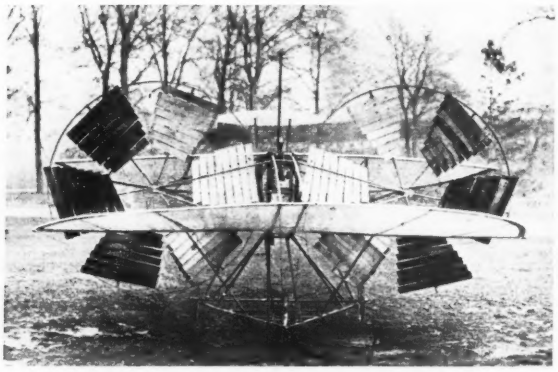


FIGURE 3. Moy and Shill's Aerial Steamer, 1875.

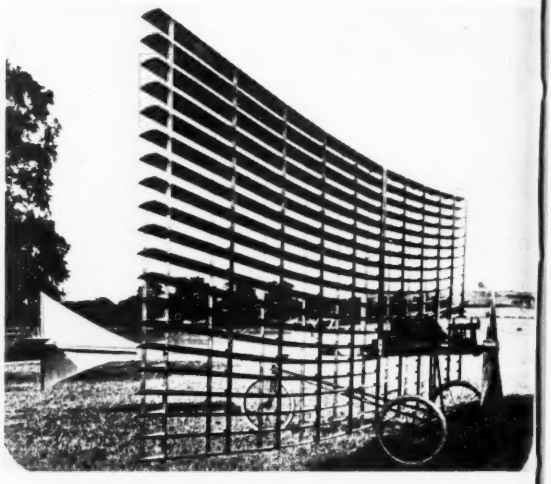


FIGURE 4. Phillips' " venetian blind " aeroplane, 1899.

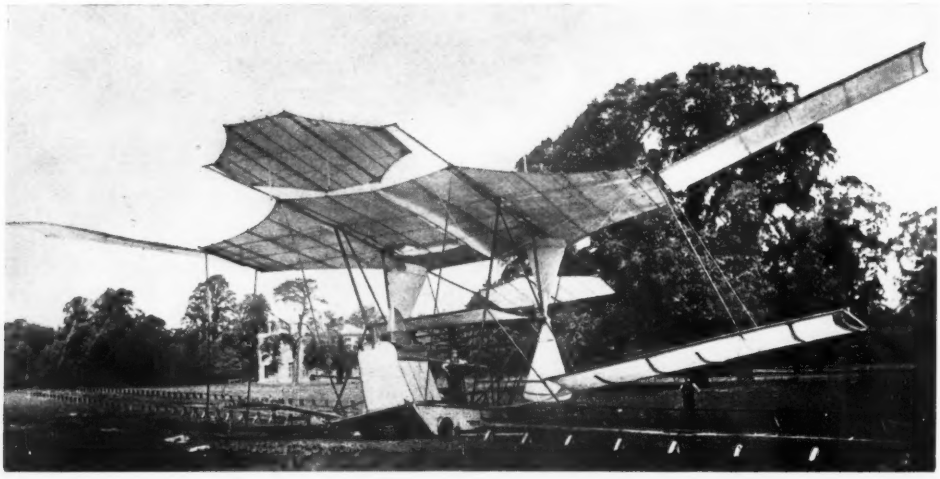


FIGURE 5. Maxim aeroplane at Baldwyn Park, 1891.

he made many gliding experiments and constructed various forms of gliders. He built an artificial hill outside Berlin, from which to glide, and in June 1895 was visited by Percy Pilcher (who was born the same year the Society was founded), an engineer who had been closely associated with Sir Hiram Maxim. Pilcher, who had been experimenting with his own type of glider, came back from his Berlin visit convinced that the conquest of the air was near.

But it was still ten years away.

Both men relied for the control of their gliders upon their own quickness of reaction and movement, the skill, indeed, of a tight rope walker in the air without the tight rope or the safety net. Both only partly understood the risks they were taking, so both practised for the sole purpose of becoming familiar with the starting and landing conditions and methods of control in the air by the movement of their own bodies, in order that they could fly "with comparative safety" to use Pilcher's own words. But one can never sit upon the centre of pressure with safety for long.

Both men planned to fit an engine into their latest glider, and both lost their lives before they could do so, through being unable to keep control of their gliders. Percy Pilcher was the first member of Council of the Society to lose his life in an air accident.

It is worth while interpolating here the comment of Wilbur Wright on Lilienthal, in his address to the Western Society of Engineers in September 1901, describing some of his own gliding flights.

> "It seemed to us that the main reason why the problem had remained so long unsolved was that no one had been able to obtain any adequate practice. We figured that Lilienthal in five years of time had spent only about five hours in actual gliding through the air. The wonder was not that he had done so little, but that he had accomplished so much. It would not be considered at all safe for a bicycle rider to attempt to ride through a crowded city street after only five hours practice, spread out in bits of ten seconds each over a period of five years; yet Lilienthal with this brief practice was remarkably successful in meeting the fluctuations and eddies of wind gusts. . . ."

In the early 1890's Hiram Maxim, another energetic member of the Society, well-known for the gun named after him, built his famous steam-engine-driven aeroplane weighing some 8,000 lb. Maxim decided to test it along special rails to ascertain the total lifting power before venturing on free flight.

The steam engine developed 360 h.p. and he was confident that at a speed of 45 m.p.h. the wings would lift 10,000 lb. He obtained the lift he expected, but the upper guard rails which had been designed to prevent free flight, failed to hold the machine down, and it crashed out of control.

Writing in the *North American Review* in October 1895, he said "the experiments have led me to believe that the flight of man is possible even with a steam engine and boiler. I would, however, advise the young engineers who may read this paper, if they wish to do something to advance the science of aviation, to turn their thoughts in the direction of the petroleum motor . . . I believe it is the petroleum motor that we must look to in the future as being the engine which will drive our flying machines."

Maxim spent over £20,000 on his experiments with no success from a flying point of view, though he showed that great weights could be lifted in the air with the power then available. Many of these early pioneers lost everything in their search for the secret of flying. Horatio Phillips, a member of the Society for many years, whose "venetian blind" machine and curved aerofoils are well-known, had to give up after spending close on £5,000 in the second half of the nineteenth century, when such a sum was a substantial fortune.

Thomas Moy, who for over twenty years continued to experiment, died in poverty, after spending over £4,000. The work and ideas of Moy, a competent engineer who became a member of the Society in 1870, are recorded in many pages of the Society's Annual Reports. In one of these Reports it was said of his machine that it was "the most determined attempt at solving the problem that has yet taken place." Octave Chanute, in *Progress in Flying Machines*, gives one of the fullest descriptions published of Moy's design.

The steam engine used was designed by Moy's partner Shill, and weighed with boiler 80 lb., developing 3 h.p. The aeroplane, fitted with a tricycle undercarriage, weighed 216 lb., a little less than 2 lb. per sq. ft. of surface. In between the fore and aft planes were two large "aerial wheels," which were expected to develop sufficient thrust to lift the machine into the air at a forward speed of 35 m.p.h. The maximum speed reached, however, was only 12 m.p.h., for the resistance of the structure had been very much underestimated.

E. P. Frost, for many years a member of Council and for a time President of the Society, spent large sums carrying out experiments near Cambridge in the last quarter of the nineteenth century, with a flapping wing machine, with beautifully made feathers of metal. He was a rich man, able to indulge in his hobby, but he did not get to the stage of making even controlled short hops, a failure he attributed to the lack of a light engine. As Frost tried to imitate the bird, so Major Moore, another member, tried to learn from the flying fox, with equal lack of success, though he fully persuaded himself, and half persuaded a few others, that he was on the right lines.

Lawrence Hargrave, elected a member of the Society in 1897, was born in England and emigrated to Australia in the year of the Society's birth. He carried out a long series of remarkable experiments between 1884 and 1909 which will always find a descriptive and honoured place in any history of aeronautics. He published his discoveries freely for any one to use.

Hargrave was the designer of the first rotary engine and, later, the box kite which made him famous and on which Santos Dumont made the first European flight in 1906. The Hargrave box kite, in fact, as early as 1894, had greater lift and stability than any other form of kite up to that time, and following experiments with it Hargrave was able to put forward sound suggestions

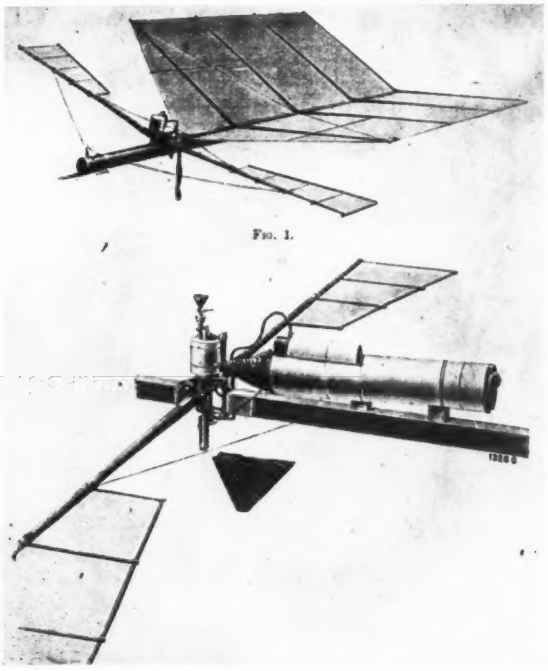


FIG. 1.

FIGURE 6. Hargrave's power-driven models.

for the power-driven aeroplane. In May 1899 he read a paper before the Society on the subject. In the same number of the JOURNAL giving a report of the lecture appeared a description by A. A. Merrill of Boston, U.S.A., of some gliding experiments and flights he had made to find the shape of curved wings giving greater lifts than any other known.

The work of Samuel P. Langley during the fifteen years preceding that of the Wrights cannot be overlooked in any description of the latter's experiments. Langley was a scientist of standing in America, and in a powerful position as Secretary of the Smithsonian Institution to obtain news of any scientific advances in any part of the world. He became interested in the possibility of flying in 1886 and began experiments with a whirling table of some 60 ft. in diameter.

Langley succeeded in May 1896 in making a model, driven by a steam engine, fly a distance of some 3,000 feet and in November of the same year in flying a second model for a distance of three-quarters of a mile at approximately 30 m.p.h. On any showing, these were results which justified the not inconsiderable optimism of Langley and others that the possibility of building a full size man-carrying machine was not outside the range of normal probability. Langley realised the difference between model and full-scale results, but " I can entertain no doubt that they do so hold far enough to afford assurance that we can transport weights many times greater than that of a man," he wrote after the success of his model experiments.

Two years later Langley considered the construction of a man-carrying aeroplane of between 600 and 700 lb. weight, including 150 lb. for the pilot. The structure and accessories weight was reckoned to be 250 lb. and that of a 24 h.p. engine 200 lb. Langley initiated then a practice which has been followed in recent years of building a quarter size model to test his ideas.

In 1903 he attempted full scale trials which, after his death in 1906, led to the controversy as to whether the machine could or could not have flown, since each attempt to fly had led to failure at the launching point. In 1914 further attempts were made to prove that Langley was on the right lines, attempts which are described later.

This very brief summary of the score or so years before the Wrights began experimenting, may perhaps be completed by reference to the Presidential address of Major Baden-Powell to the Society on December 4 1902, an address dealing with recent aeronautical progress and the future of aerial navigation. The Smithsonian Institution considered it important enough to publish it as a reprint (No. 1379).

Baden-Powell had kept in touch all those years with most attempts to fly. The period he covered in his address was mainly 1899-1902, those crucial years when the Wrights were carrying out their gliding and wind tunnel experiments which culminated in the triumphant achievement of the following year. This address is given by a contemporary who missed little in aviation at the time, and one who reflects the way of thought in those years before the Wrights succeeded, a way of thought it is essential to understand, if an adequate appreciation can be given of the final success of December 17 1903, and in the outlook and knowledge of those days.

" During these three years," said Baden-Powell, " many great events have taken place in the aeronautical world. Count Zeppelin's monster air ship . . . has been completed, and has made successful ascents, although, I much regret to have to add, has not succeeded in travelling through the air at a sufficient speed to warrant it being considered a practical success. Then we come to M. Santos Dumont's many more or less successful trips in his navigable balloons . . . unfortunately the actual results attained carry us so little beyond what was accomplished twenty years before by MM. Renard and Krebs that one begins to think whether we have not nearly reached the end of the tether as regards the propulsion of balloons. . . . The latest accounts of M. Lebaudy's balloon seemed to make out that it has accomplished more, but we must await the results of more prolonged trials before we come to any decision. . . .

" Besides these we have heard of various experiments with flying machines proper. Herr Kress is said to have risen off the surface of the water, but owing to some mismanagement the machine turned downwards and fell in the water again. In Australia Mr. Hargrave has constructed a large machine. In America Mr. Wilbur Wright and his brother have been making wonderful progress with gliding machines, and Professor Langley has been hard at work constructing a large new machine. . . .

" . . . It is only recently that the results have been published of the valuable experiments with

aerial-screw propellers which Mr. W. G. Walker conducted for Mr. Alexander. . . ."

Baden-Powell discussed the dirigible balloon and came to the conclusion it could never get up sufficient speed to be of any real use. He then turned to the heavier-than-air types of flying machines. He began with gliders.

"I received a letter only a few days ago from Mr. Chanute, than whom there is probably no greater authority living on soaring flight. He says he had just returned from witnessing this season's gliding experiments of the Brothers Wright, and that 'they have made a very considerable advance since last year, and now glide at angles of 6° to 7°, sustaining 125 to 160 lb. per net horse power. Wright is now doing nearly as well as the vulture, is not far from soaring flight, and I am changing my views as to the advisability of applying a motor.'

"I think this is a most remarkable statement, and there really seems no reason why such experts, having attained proficiency in the delicate art of balancing themselves according to the various puffs and currents of air, should not be able to soar away on the wings of the wind and remain indefinitely in mid air."

The original of Chanute's letter (*see* Fig. 11), in his own handwriting, dated October 1902, is now in the possession of the Society. An earlier one dated March 4 1902, to Alexander McCullum, another member of the Society with whom Chanute corresponded, was written before the Wrights had gone to Kitty Hawk in 1902 and runs:

"I am very pleased that you appreciate the advance which the Wrights have achieved over my 1896 and 1897 experiments. There is no mechanism for deflecting the extremities of the wings; they are simply warped by pulling a cord with the hands, the joints of the uprights being somewhat loose, where they attach to the main spars. Landing is effected by

FIGURE 7. Langley ¼ size model in flight, August 8 1903.

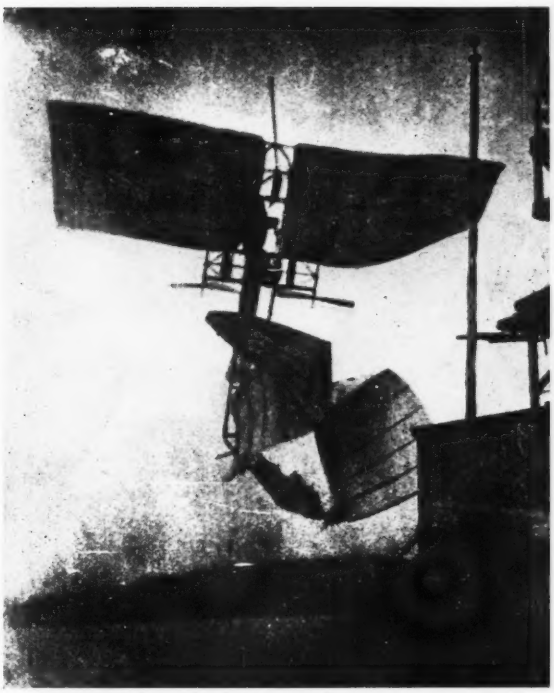


FIGURE 8. Langley aeroplane collapsing on launching, December 8 1903.

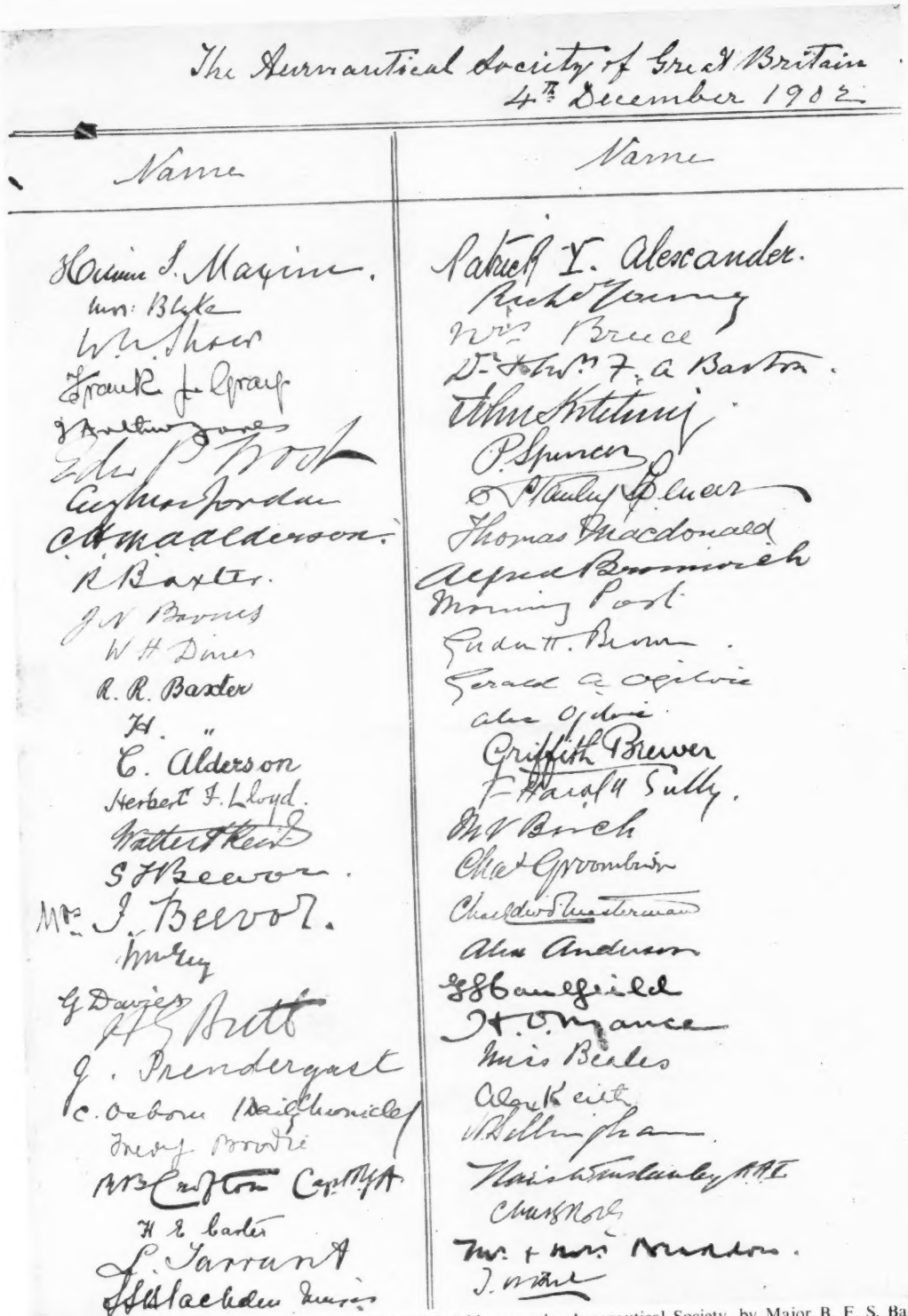
slowing up through a glance upward just before touching the ground. This glance is produced through the rudder at the front. Motion being nearly stopped the apparatus lands squarely, and the man, still prone, inhales a little sand, only a few grains. The Wrights have no intention of adding a motor yet. They will try more gliding experiments the next autumn, when vacation time comes."

These gliding experiments were so outstandingly successful that by the end of 1902 the Wrights were looking round for a suitable motor to use on their next visit in 1903 to Kitty Hawk.

Baden-Powell in his lecture discussed the direct vertical lifting power of airscrews, following W. G. Walker's tests, and came to the conclusion, "Even if not a practical form of machine for travelling through the air, it would be a most interesting experiment to try."

"Finally," he continued, "we come to that variety of aerial machine that has been adopted by most inventors and which seems to promise the most satisfactory results. I mean what is known as the aeroplane. Sir Hiram Maxim brought this prominently forward many years ago, and both he and Professor Langley have proved theoretically that it is the most economical form of apparatus: that is to say, that a given weight can be supported with less engine power than by any other methods.

"Great progress has also been achieved in recent years in this line. Lilienthal pointed out the greater efficiency of curved surfaces as compared to flat ones. Phillips and Hargrave experimented further with


The Aeronautical Society of Great Britain
4th December 1902

Name

Hiram S. Maxim.
Wm. Blyth
W. Napier Shaw
Frank H. Wenham
J. Baldwin Jones
Edw. P. Frost
Cuthbert Jordan
A. Maclaverock
R. Baxter
J. N. Barnes
W. H. Dines
R. R. Baxter
H. "
C. Alderson
Herbert F. Lloyd.
Walter Reid
S. J. Beevor.
Mrs. J. Beevor.
Wm. Ley
G. Davies
H. E. Butt
J. Prendergast
C. Osborn Baldwin
Percy Browne
W. B. Crofton Capt. R.A.
H. R. Carter
L. Tarrant
H. Blackden Junior

Name

Patrick Y. Alexander.
Richd. Young
Wm. Bruce
D. Hutchison F. A. Barton.
Alan Muntz
P. Spencer
D. Wauchope P. Shaw
Thomas Macdonald
Alfred Bromwich
Morning Post
Gordon H. Brown.
Gerald A. Ogilvie
Alec Ogilvie
Griffith Brewer
F. Harold Sully.
W. V. Birch
Chas. Groombridge
Chas. Dawson Masterman
Alex Anderson
G. S. Bousfield
H. O. Mance
Miss Beales
Alex. Keith
W. Bellingham
Maurice Hanley R.A.E.
Chas. Rolls
Mr. & Mrs. Rendall.
J. Wade

FIGURE 9. First page of attendance sheet at the Presidential Address to the Aeronautical Society, by Major B. F. S. Baden-Powell, December 4, 1902. Among the members of the Society who signed this sheet are Sir Hiram Maxim; W. Napier Shaw, the well-known meteorologist; W. H. Dines, whose work on air pressures and kites is as well known as his meteorological work; E. P. Frost, who joined the Society in 1876, became its President, and spent many years experimenting with an ornithopter; Patrick Alexander, who did so much for the Society and aviation, and C. H. M. Alderson, who rescued the Stringfellow relics from oblivion, so that Alexander could present them to the Victoria and Albert Museum on behalf of the Aeronautical Society; Walter Reid, an authority on explosives, who became a member of Council; Dr. Barton, whose airship experiments were causing much interest; Alec Ogilvie, an undergraduate at Cambridge interested in flying kites and gliding, and Griffith Brewer, who had then won fame as a balloon pilot, both men became close friends of the Brothers Wright; the Hon. Chas. S. Rolls, the Rolls of Rolls-Royce, who was killed flying at the Bournemouth Meeting in 1910; and H. O. Mance, now Sir Osborne Mance, the oldest member of the Society. He joined in 1899. The second oldest is Alec Ogilvie, who joined in December 1901.

aerocurves. Considering how much more we know about the subject now than when Maxim first built his machine, it looks as though we might really hear of great results shortly from America or Australia.

"Our present position is, then, a hopeful one. . . . Large flying machines, giving practical experience of their construction have been built. Good sized models have flown well through the air. Gliding machines, balanced and controlled by human effort, have been maintained in the air for considerable periods and have descended at very gradual angles. And, what is of the greatest importance, small engines, giving great power for their weight, have steadily improved year by year, leaving but little for us to desire in this respect.

"All that we require, then, to attain practical flight, is to make a machine only slightly better than those already in existence. To accomplish this all that is required is a certain amount of skill and a good deal of money."

The Wrights had the skill, but certainly had not a good deal of money. Yet they solved a problem which, before them, had cost a good deal of money without the necessary amount of skill.

"There has often been a lot of wild speculation about what might happen when flying machines are introduced into everyday life," continued Baden-Powell, "but it may be worth while considering for one moment what is likely to result, so as to judge whether the matter is one really demanding an effort to accomplish. . . .

"Whatever the exact form the apparatus may take, we may assume that it will possess certain characteristics. The first of these is that it will travel very fast. . . . In the aerial highways we have greater latitude. We have height as well as length and breadth. We can choose our particular altitude and stratum to travel in, so that perhaps 1,000 machines could cross over the same spot at the same time without colliding.

". . . Once a practical flying machine existed, the uses to which it might be applied are varied and important. Primarily it would be an incalculably valuable engine of war. One can scarcely imagine any invention which could have a greater effect on the conduct of warfare. . . . There is the likelihood of a revolution in our ordinary modes of travel by one infinitely more rapid, cheap and convenient. There is also good reason for supposing it would be economical."

Baden-Powell was no economist, for he continued,

"No rails or permanent way need be laid on the billows of the clouds. . . . Going from place to place 'as the crow flies' shortens the route and adds to the economy . . . when we can order round our aerial motor to take us straight to our destination, passing equally well over land and water, towns, or cornfields, independent of traffic and roads, then only shall we realise what real convenience of travel is."

When . . . alas!

The Gliding Years, 1900 - 1902

"If the heavens then be penetrable, and no lets, it were not amiss to make wings and fly up; and some new-fangled wits, methinks, should some time or other find out".

Robert Burton (1577-1640)
Anatomy of Melancholy.

"When we studied the story of the loss of life, financial disaster, and final failure which had accompanied all attempts to solve this problem of human flight," said Wilbur Wright in 1912, a few months before he died, "we understood more clearly than before the immensity and the difficulties of the problem which we had taken up."

He and his brother Orville showed a passing interest in flying when they read of the death of Otto Lilienthal in 1896 in an accident while gliding outside Berlin. At that time Wilbur was in his 29th year and Orville was just 25 years of age. They were directors of the Wright Cycle Co. of Dayton, Ohio, working directors.

It was not until 1899 after reading a book on ornithology that they began seriously to study the problem which "seemed to us almost in contradiction of the laws of nature," to quote Wilbur Wright.

"We had heard that the Smithsonian was interested in matters relating to human flight. In response to our inquiry, we received a reply recommending Langley's *Experiments in Aerodynamics*, Chanute's *Progress in Flying Machines* and the *Aeronautical Annuals* of 1895, 1896 and 1897, edited by James Means, giving reports of efforts being made to solve the flying problem. The Smithsonian also sent us a few pamphlets extracted from their annual reports, containing a reprint of Mouillard's *Empire of the Air*, Langley's *Story of Experiments in Mechanical Flight*, and a couple of papers by Lilienthal relating to *Experiments in Soaring*.

"When we came to examine these books we were astonished to learn what an immense amount of time and money had been expended in futile attempts to solve the problem of human flight. Contrary to our previous impression, we found that men of the highest standing in the professions of science and invention, had attempted the problem. Among them were such men as Leonardo da Vinci, the greatest universal genius the world had ever known; Sir George Cayley, one of the first men to suggest the idea of the explosion motor; Professor Langley, secretary and head of the Smithsonian Institution; Dr. Bell, inventor of the telephone; Sir Hiram Maxim, inventor of the

automatic gun; Mr. O. Chanute, the past President of the American Society of Civil Engineers; Mr. Chas. Parsons, the inventor of the steam turbine; Mr. Thomas A. Edison, Herr Lilienthal, M. Ader, Mr. Phillips, and a host of others."

The difficulty the brothers had to face was simply that there was no actual flying experience nor full-scale flying data upon which they could draw. There were theories, plenty of them, and data on the forces on flat plates held at various angles in the wind (hadn't the Society itself carried out experiments as early as 1870?) and on movements of centre of pressure, and on various types of curved wings and the like, kite flying and gliding, but no actual flying. And most of what they read appeared either unreliable or did not seem to lead anywhere. Octave Chanute, who did so much to encourage the Wrights, indeed, plotted the results of many theories and experiments up to the year 1891 and his curves showed how great were the discrepancies.

The more the Wrights read of the work and experiments of Langley, Lilienthal, Chanute, Pilcher, Maxim and others, the more certain it appeared to be that the problem of maintaining equilibrium presented far greater difficulties of solution than that of constructing wings sufficiently light and strong or of designing and making a light power unit. They were, indeed, confident

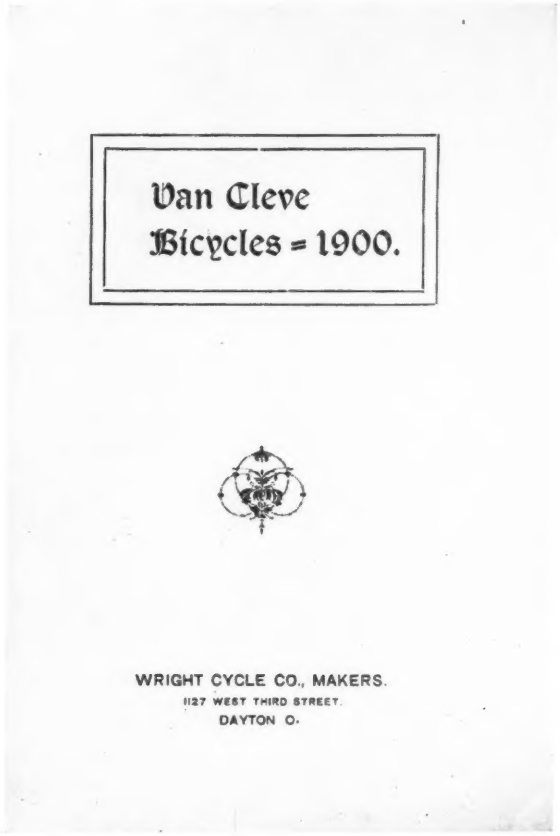


FIGURE 10. Title page of the Catalogue of Van Cleve Bicycles manufactured by Wilbur and Orville Wright.

they could solve, as practical working engineers, these last two problems. Wilbur Wright said that "the problem of equilibrium had been the real stumbling block in all serious attempts to solve the problem of human flight, and that this problem of equilibrium in reality constituted the problem of flight itself."

History showed, only too often, that until Lilienthal had begun his own gliding experiments all attempts to fly ended in inevitable disaster to the machine, the experimenter, or both. Lilienthal and Pilcher both lost their lives after considerable gliding experience, without learning the solution of the aerodynamic problem of control. Those who escaped disaster did so more by good fortune than good knowledge. The observations of Mouillard, Chanute and others on the way birds maintained their equilibrium under all conditions of flight, did not convince the Wrights that human flight was to be successful by imitating avian methods as far as mechanically possible. If there were one thing characteristic about the two men it was the trust they had in their own observations and their own experiments as against those already recorded by others, for the observations and experiments of the past had failed to provide the flying machine of the present, and that was exactly what the two brothers were trying to provide themselves.

Not that they did not believe the solution could not be found from a study of natural flight, for they were convinced something vital had been overlooked. It was this something vital they found while watching pigeons flying, particularly the movements of one bird which oscillated rapidly from side to side, "that is, it tilted so that one wing was elevated above its normal position and the other depressed and then tilted in the opposite direction." It was this observation which enabled the Wrights to hit upon the system of warping of the wing tips of their aeroplane, the first real step towards safer flying. This step was of such importance in their final triumph that I quote from Wilbur Wright's own words:

> "In considering possible explanations of the method used by the bird in this instance, the thought came that possibly it had adjusted the tips of its wings about a lateral transverse axis so as to present one tip at a positive angle and the other at a negative angle, thus, for the moment, turning itself into an animated windmill, and that when its body had revolved on a longitudinal axis as far as it wished, it reversed the process and started to turn the other way. Thus the balance was controlled by using dynamic reactions of the air instead of shifting weight. So far as fore and aft balance is concerned, this seemed to be accounted for by fore and aft movements of the wings, as claimed by Chanute.
>
> "In speculating on possible methods of constructing a flying machine to carry a man, we hit on the idea of providing a structure consisting of superposed surfaces rigidly trussed along their front and rear margins, somewhat after the general style of the Chanute 'double decker' but not trussed from front to rear. The connections of the uprights joining the two surfaces were to be hinged so that the upper

O. CHANUTE,
CONSULTING ENGINEER,
413 E. Hudson St.,
CHICAGO, ILLINOIS.

WOOD PRESERVING A SPECIALTY.

CHICAGO, ILL., Oct 21st 1902

B. Baden Powell
32 Princes Gate - London S.W

My dear Mr Baden Powell.

I am very glad that you are back from S. Africa, and to get once more in touch with you.

I received your letter of Sep 27th upon my return from witnessing this season's gliding experiments of the brothers Wright. They have made a very considerable advance since last year, and now glide at angles of 6° to 7°, sustaining 125 to 160 lbs per net horse power. I mail separately Mr Wright's paper of last year, (he will write another this year) and a copy of the rules for the St Louis contests in 1904.

Wright is now doing nearly as well as the Vultures, is not far from soaring flight, and I am changing my views as to the advisibility of applying a motor.

I thank you for calling my attention to the Illustrated Scientific News, and enclose my subscription for 2 copies, and 14/.

I have seen in the Aeronautical Journal brief, (& brief) references to your aerial achievements in South Africa, and shall hope to see in print fuller accounts of them, as well as a reprint (if you have one) of your articles in the Encyclopedia Britannica.

Faithfully yours
O. Chanute.

FIGURE 11. Original of Chanute's letter of October 21 1902 to Baden-Powell. (Slightly reduced in size.)

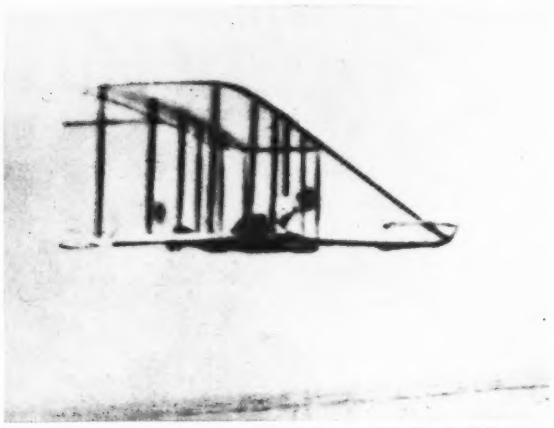


FIGURE 12. Wilbur Wright gliding at Kill Devil Hill.

surface could be moved forward or backward, with reference to the lower surface. This would have an effect on fore and aft balance similar to that produced by the fore and aft movement of the wings of birds. I refer, of course, to the slight fore and aft movements of the wings of soaring birds, like the buzzards and hawks, made for the purpose of balancing. It is an entirely distinct thing from up and down flapping. It was designed to move either end of the upper surface forward or backward by a separate lever, one controlling one tip and the other the other. If both levers were pressed forward the upper surface would be moved bodily forward and the machine would turn upward, but if one lever were thrown forward and the other backward, one tip of the upper surface would move forward and the other backward. Thus there would be no change in the general position of the upper surface to the front or rear of its normal position, but the entire structure, consisting of both upper and lower surface, would be given a warp like that shown in our patent. We reasoned that by imparting such a warp we could control lateral balance of our machine, either for the purpose of balancing or steering, as we had noticed when the birds were tilted they circled round the depressed wing."

Alec Ogilvie, a member of the Council of the Society, in his Wilbur Wright Memorial Lecture in 1922, explained how the Wrights hit upon the actual warping method they used in their biplane.

"The Wrights knew that they wanted to give different angles of incidence to the two wing ends to obtain the lateral control which they saw from accounts of previous experiments was necessary. Wilbur was explaining to an interested audience* what was wanted and was using an old open-ended cardboard box which had probably contained puffed wheat or some other strange American breakfast food, to illustrate his remarks. As he was holding it by the two ends and twisting it about, he suddenly realised that in his hands he had a biplane structure firmly braced in two planes but able to be twisted at the two open ends, and that this was just what was wanted for the lateral control of a flying machine. In the first machines the warping wires ran in the fore and aft direction and not forming the bracing of the back spars in a lateral direction as we used to know them.

"The elevator or horizontal rudder as it was called was another new device worked out to meeting another well-known difficulty, that of controlling the movement of the centre of pressure. The front part was fixed, and the back edge could be moved up and down. The effect was that in the neutral position the plane was flat, while a movement of the back edge gave it a curve upwards or downwards with an increasingly powerful action either way."

From practical considerations they found that the fore and aft control could be better obtained by using a small movable horizontal surface in front of the main planes. This, with the warping of the wing tips, would provide all the necessary balancing control. No tail surface, either vertical or horizontal, was provided in their first glider.

In the late summer of 1899 Wilbur and Orville Wright built a small kite model to test their ideas. This was a biplane kite of about 5 ft. span and 13 in. chord and the warping of the wing tips, or the movement of the top wing forward, was done by manipulating cords from the ground.

"We felt that the model had demonstrated the efficiency of our system of control," said Orville afterwards. "After a little time we decided to experiment with a man-carrying machine embodying the principle of lateral control used in the kite model."

After studying reports from the Weather Bureau at Washington, the brothers picked on Kitty Hawk in North Carolina for their first experiments. Kitty Hawk was on the narrow sand bar which separated Albemarle Sound and the Atlantic Ocean. The bar was flat and treeless, with a few sand hills, and extended to the south of Kitty Hawk for a distance of nearly five miles. The prevailing winds blew steadily between 15 and 20 miles an hour. It was an ideal place for gliding experiments. There were three sand hills which the Wrights used in their experiments, known as the Big Hill or Kill Devil Hill, the Little Hill, and the West Hill, with heights of about 100, 30, and 80 feet respectively. The Wrights used the Little Hill from which to fly their glider as a kite. The slope of the hill was 7°. "Testing

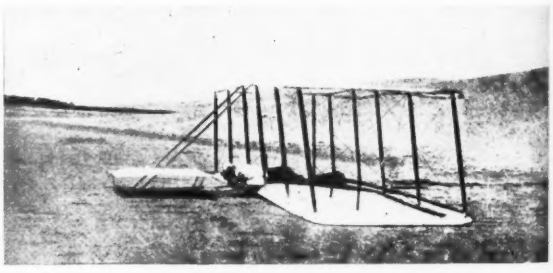


FIGURE 13. 1900 glider coming in to land at Kill Devil Hill.

* Orville and Katharine Wright and a Miss Harriet Silliman.

a gliding machine as a kite on a suitable slope, with just enough wind to sustain the machine at its most favourable angle of incidence, is one of the most satisfactory methods of determining its efficiency," said Wilbur Wright afterwards, in his second lecture before the Western Society of Engineers, in June 1903.

The brothers were only able to spare their holiday time for experimenting, and so it was not until the second week in October that the 1900 glider was ready.

They had accepted the data published by Lilienthal and they calculated that the glider, the first they had built, would fly in a wind of 21 m.p.h. at an angle of incidence of 3°. The total surface was 165 sq. ft. On their first attempt to fly it as a kite, with one of the brothers lying prone on the centre of the lower wing, a position adopted throughout all the experiments in order to lessen air resistance, the wind ranged between 25 and 30 m.p.h., but the angle of incidence was nearer 20° than 3°. With higher winds the brothers found they could only use the glider purely as an unmanned kite, as the angle of incidence was too great for the pilot to operate the controls himself.

Clearly there was something incorrect with the data they had been using, so the Wrights decided to make a series of full scale tests of lift and drag, the first full scale tests ever made, using the glider as a kite in a wind of known speed. These tests showed that the lift was much less than had been calculated and the drag only about half of what had been expected.

The first free glides were made in a wind of about 14 m.p.h. The brothers had expected, when they arrived at Kitty Hawk, to have many hours of practice, for they had relied upon getting sufficient lift at lower wind speeds than they had found to be possible in practice. As a result, their total gliding time that year was only two minutes! Yet in those two minutes and the periods when the glider was flown as a kite, loaded with chains to represent the pilot's weight, and controlled by ropes from the ground, much had been learnt.

In their first short glides only the front horizontal plane was used, so that the fore and aft balance control could be learnt, without having to learn lateral balance at the same time. The moment the glider tilted laterally the pilot immediately brought it down. Straight glides of 15 to 20 seconds were usually made while the brothers acquired the necessary practice for fore and aft control. Glides were made within five or six feet of the ground in these early experiments, so that a landing could be made quickly in case of loss of control, without the fatal results which had overtaken other earlier experimenters. The weight of the glider without a pilot (taken as being 140 lb.) was 52 lb. The wings were 18 ft. by 5 ft., giving an aspect ratio of only 3·6. A space 18 in. wide was cut out of the lower plane so that the net surface was 165 sq. feet. Ash was used for the ribs and the main spars were of white pine. The wire used was 15g. spring steel.

When it came to experimenting with the warping of the wing tips the brothers ran at once into difficulties.

> "We found ourselves completely non-plussed," said Wilbur Wright. "The apparatus did not act at all as we expected. At first we were not able to determine exactly what it did do, but it was clear enough that it was not what we wanted in all respects. We repeated the trials for the purpose of determining, if possible, exactly what happened, but found this no easy task. To the person who had never attempted to control an uncontrollable flying machine in the air this may seem somewhat strange, but the operator on the machine is so busy manipulating the rudder and looking for a soft spot to alight that his ideas of what actually happens are very hazy.
>
> "We repeated the experiments time and time again, and several times barely escaped disaster. After repeated experiments we began to perceive that in landing, the machine was skidding toward the wing having the smaller angle and was facing somewhat toward the wing having the greater angle, and the wing having the greater angle seemed to touch first. As our season was now at a close we were compelled to leave the problem in this condition."

The "season" was short. The first experiments with this glider had only begun in the second week in October 1900 but on October 23 the two brothers left Kitty Hawk determined to continue their experiments the following years. That winter they built a larger glider, weighing 98 lb. against the 52 lb. of the 1900 glider, with a surface of 290 sq. ft. against 165 sq. ft. This second glider had a greater area than any tried by Chanute, Lilienthal or Pilcher.*

Gliding with the new glider began on July 27 1901 at Kitty Hawk. It proved to be less controllable than the 1900 glider due to the shift of the centre of pressure. By reducing the camber and so lessening the centre of pressure shift, glides of several hundred feet were safely made.

> "The machine, with its new curvature, never failed to respond promptly to even small movements of the rudder.† The operator could cause it to almost skim the ground, following the undulations of its surface, or he could cause it to sail out almost on a level with the starting point, and passing high above the foot of the hill, gradually settle down to the ground."

The wind was then between 11 and 14 m.p.h. The highest winds occurring during the experiments were 27 m.p.h.

Although glides were made that summer which were longer than any recorded before by any previous experimenters, the Wrights left Kitty Hawk dissatisfied with the results they had obtained, largely due to the low figure for the lift/drag ratio. The Lilienthal results had led them to expect that the ratio would have been much higher, so enabling them to obtain much more practice than they had done.

The brothers decided to carry out an independent investigation with model aerofoils. The lift they had

* A. Ogilvie, in his Wilbur Wright Memorial Lecture, May 1922, gives the surface as 308 sq. ft., but this included 18 sq. ft. of horizontal rudder. The wings were 22 ft. by 7 ft. Wilbur Wright in his diary noted: "We have experimented with a machine of over 300 sq. ft. surface."

† Horizontal.

balloon, carrying a message from the British Association in England to Scientific Confreres in France. The "Sketch" contained an account with photographs I secured.

It is unnecessary to more than mention the numerous balloon ascents, parachute descents, ascents of the monster Fish Balloon, shaped and decorated according to nature, made by myself and brothers, throughout the length and breadth of the country. But perhaps I should not close this paper without referring to the new aeronautical premises now erected by Messrs. C. G. Spencer and Sons at Highbury Grove. Here is the only specially-designed establishment for the purpose in this country including a hall with curved roof sufficiently large for the inflation with air of the large-sized balloons, in order that they may be examined, repaired, or dried. From this establishment the present season witnessed the advent of eight fully-equipped passenger balloons with aeronauts and assistants on one day. Four of these were to make simultaneous ascents in London on the 1st May on behalf of the "Sun" newspaper, and duly ascended with observers in the car of each balloon from West Ham, Barnes, the Welsh Harp, and the Crystal Palace; whilst the other four balloons, used for the purposes of advertisement, left for South Wales, where they also satisfactorily started ascents with parties in the car of each on the 1st May, in Cardiff, Swansea, Newport, and Pontypridd. Thus it will be seen that there are ample facilities for the future of balloon investigation in this country, and with the ever increasing interest in the subject, no doubt each year of the new century will be able to chronicle further progress.

PERCIVAL SPENCER.

Angle of Incidence.

By Wilbur Wright.

If the term "angle of incidence," so frequently used in aeronautical discussions, could be confined to a single definite meaning, viz., the angle at which aeroplane and wind actually meet, much error and confusion would be averted. But many of the best writers use this term loosely and inexactly, with the result that their calculations and explanations of phenomena are thereby often rendered of little value, and students are misled.

If a plane be held stationary in a horizontal wind (Fig. 1), the angle of incidence A C D will be equal to the angle with the horizon. But if the wind have an upward trend, the angle of incidence will be increased to A C D^2. A calculation based on the assumption that A C D still remained the true angle would, of course, be seriously in error.

If it be assumed (Fig. 2) that the wind moves from D^2 to C, while the plane moves from E to C, the angle of incidence will become A C D^3. The wind having an apparent horizontal speed of F C+E C, which is equal to F^2 C, as compared with a vertical speed of D^2 F, the wind will appear to strike the plane from the direction D^3 C, thus making its angle of incidence A C D^3 instead of A C D^2.

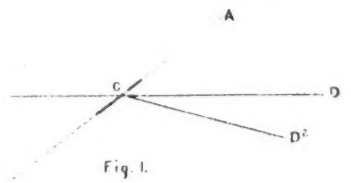


Fig. 1.

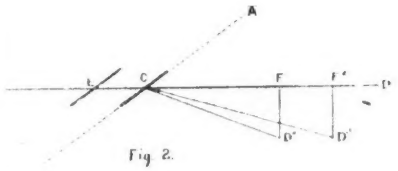


Fig. 2.

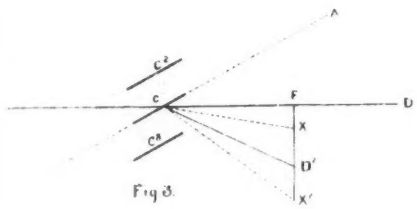


Fig 3.

Taking still another case (Fig. 3), in which the wind moves from D^2 to C, while the plane is rising from C to C^2 the angle of incidence will be A C X. The horizontal speed of the wind will be F C, and its apparent vertical speed D^2 F−C C^2 = X F, so that the wind will appear to strike the plane from the direction X C. If the plane had fallen from C to C^3 the angle of incidence would have been A C X^2, since the vertical motion would now have been D^2 F+C C^3−X^2 F.

FIGURE 14. On this and the opposite page are reproduced from the JOURNAL of July 1901 Wilbur Wright's paper on "The Angle of Incidence," the first paper he wrote.

A study of the foregoing will lead to the conclusion that in order to obtain the angle of incidence, it is first necessary to know correctly (1) the angle of the plane with the horizon; (2) the horizontal speed of the wind; (3) the vertical speed of the wind; (4) the horizontal speed of the plane; (5) the vertical speed of the plane. Now, since the probability of obtaining five correct simultaneous measurements is very slight when the observation is taken in the open air, and since the soaring angle is not supposed to exceed three degrees, it is evident that calculations based upon observations of soaring birds are of exceedingly doubtful value.

But though direct attempts to calculate the angle of incidence promise little for accuracy, another method remains by which approximately correct results may be obtained. The tables of Langley, Lilienthal, Chanute, and others give with a good degree of accuracy, the vertical component of the normal pressure at all angles and speeds, both for planes and curved surfaces. Now, since the elements of these tables are four, viz., area, speed, angle, and lift, it follows that three factors being known the fourth may readily be obtained. The angle of incidence may be calculated in any case where speed, lift, and area are commensurable. Of these, area may be obtained by actual measurement. Lift is equal to weight supported, and can also be exactly measured. Speed alone requires to be calculated at the instant the observation is made. Thus the opportunity for error is reduced to a single item, and this the one which affects the result least seriously in case of a slight error. It is easier to measure speeds than angles, and errors are less costly. There is, of course, a possibility of error in the tables, but the results have been confirmed by the experiments of independent observers, and are believed to be substantially correct. Calculations of the angle of incidence based upon this plan would scarcely be so seriously in error as that of a well-known writer based upon observations of soaring gulls, in which he obtained from his measurements of angles and speeds an angle of incidence which called for an upward lift of nearly three pounds upon a two-pound bird. It was his idea that the excess of lift was expended in raising the bird above its original level. This, however, is scarcely a satisfactory explanation of how a lift of three pounds could be applied to a two-pound bird in contradiction of the law that action and reaction are always equal. It would be more reasonable to assume that the excessive lift never existed, but that the upward motion of the bird kept the angle of incidence (Fig. 3) reduced to a point where the lift was just equal to the bird's weight all of the time.

If students of aeronautical problems will constantly bear in mind that (1) area of surface; (2) weight or lift; (3) relative speed are the only factors concerned in determining the angle of incidence, many errors will be detected and much trouble saved. It is clear that a bird, instead of possessing full control of its angle of incidence (as writers sometimes assume), is, in fact, almost powerless to change it. The bird is really itself controlled by a kind of automatic governor, for a gust of wind which tends to increase the lift is balked by the fact that the weight of the bird is not sufficient to furnish the required reaction, and the bird must either float back horizontally with a speed equal to the increase in the velocity of the wind, or it will involuntarily be raised at a speed sufficient to keep its angle of incidence at a point where the increased lifting pressure naturally due to the increased speed will be exactly counterbalanced. Nevertheless the bird can, to a limited extent, affect its area, its weight, and its speed, and thus indirectly its angle of incidence also. Its area may be reduced (and its angle increased) by partly folding its wings, but as, in actual practice, a folding of the wings always accompanies an increase of relative velocity (which produces a decrease in angle), the real effect is to preserve the original angle instead of changing it. The apparent weight may be momentarily increased by a sudden curve in the direction of motion, in which case the momentum of its body acts to produce a centrifugal force which increases the downward pressure on its wings, and thus requires an increase in the angle of incidence to furnish the required extra support. Speed may be controlled by increasing or decreasing the elevation of the bird or its rate of fall. But none of these changes in speed, area or weight, quickly and permanently affect its angle of incidence. The bird can at will vary its angle with the horizon, even to the extent of three hundred and sixty degrees in less than a second, as when it turns a complete somersault in the air; but its angle of incidence probably does not vary as much as one-twentieth of that amount in the same case. It is very important to distinguish carefully between the angle of incidence, and the angle with the horizon, as the latter has nothing at all *per se* to do with the former. By keeping the distinction carefully in mind, the student will quickly obtain new ideas of the correct explanation of the action of the Penand tail used by Lilienthal, Pilcher, and Chanute; and correct the sequence of cause and effect in many explanations of phenomena which occur in aeronautical writings.

Since the formulation of a principle into a rule often serves to fix it more prominently in the mind, the writer ventures to offer the following:—

Rule.—The angle of incidence is fixed by area, weight, and speed alone. It varies directly as the weight, and inversely as the area and speed, though not in exact ratio.

FIGURE 14. Wilbur Wright's paper "The Angle of Incidence" continued.

obtained had only been about one-third of that expected from the Lilienthal figures. Wilbur Wright had reckoned that with only five minutes gliding practice a day their experiments full scale would be well worth while, but that average had not been reached, and he felt depressed enough to express the opinion that man would not fly in a thousand years.

In that now famous lecture (surely one of the most significant aeronautical lectures ever delivered), "Some Aeronautical Experiments," read before the Western Society of Engineers on September 18 1901, Wilbur Wright described the experiments he and his brother were then beginning,

> "to accurately determine the amount and direction of the pressure produced on curved surfaces when acted upon by winds at the various angles from zero to 90 degrees. These experiments were not yet concluded, but in general they support Lilienthal in the claim that the curves give pressures more favourable in amount and direction than planes; but we find marked differences in the exact values, especially at angles below 10 degrees."

Wilbur Wright did not give a description in his lecture of the apparatus first used in these classic experiments, nor did any description appear for many years. It consisted of a bicycle wheel mounted horizontally on tubing from the handle bars of one of their bicycles. On this wheel was fixed, on a spindle, to the rim, a flat plate and, at 120° round the rim, fixed in a similar way, one of the curved surfaces to be tested. The angle of incidence of the latter surface could be adjusted until the lift balanced against the resistance of the flat plate, when the bicycle was being ridden.

Although the ratio of the lift of a curved surface to the resistance of the flat plate could be found in this way, the method did not enable worth while results to be obtained at small angles of incidence. A new device was rigged up in which two model surfaces were attached to an arm and made to balance in an air stream which was forced through a box, open at both ends, from a fan driven by a 2 h.p. engine. This was the first attempt of the Wrights to make use of a primitive form of wind tunnel.

Later in the year the first two methods were improved upon by the construction of a small square-sectioned wind tunnel.

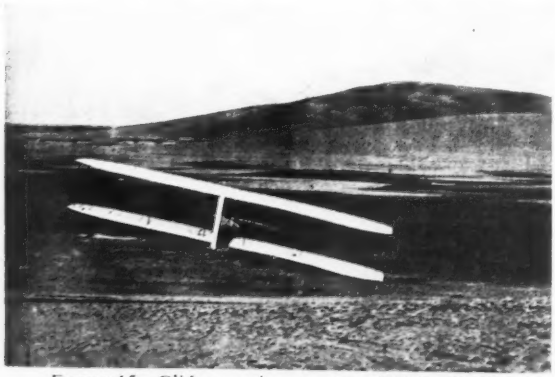


FIGURE 15. Glider warping on a turn, Kill Devil Hill.

Details of these early experiments in the true spirit of scientific investigation were, unfortunately, not made widely known for many years, for though close friends of Orville Wright had seen the metal aerofoil sections used, the wind tunnel and the apparatus by which the measurements had been made and upon which final success had been dependent, and the note books in which the precious records were kept, and the diary of Orville Wright giving an account of the work of himself and his brother, little information had been publicly released.

This reticence led to a great deal of misunderstanding in later years about the real quality of the achievements of the Wrights. Many, indeed, were misled about the basic nature of their work. F. W. Lanchester, in a letter to the Secretary of the Society in March 1909, wrote, after a visit to France where Wilbur's flying had astonished the whole world,

> "The general opinion over there, with which I concur, is that he is simply an empiric; he and his brother have evolved a flying appliance and learned to fly with it, they have also incidentally accumulated a considerable amount of practical information and experience; but when any questions are asked as to their laboratory experiments, Wilbur Wright assumes an air of mystery, and it is impossible to get anything out of him of an exact kind, even to the amount or method of experiment employed."

I do not doubt that Lanchester, of all people, would have been delighted to learn what the amount and nature of those experiments were, and to have altered his opinion, if he had lived.

The question has been asked, Why did not the Aeronautical Society obtain from the Wrights particulars of their experimental work, so that the accusation could not be made that their success was due to a lucky chance?

The answer is that the Society did try to obtain the information, but without success.

On May 1 1912, Griffith Brewer wrote to the Secretary of the Society, T. O'B. Hubbard:

> "It has occurred to me that if the Aeronautical Society could secure the original calculations and description of the experiments which were carried out by Wilbur and Orville Wright preparatory to making their flying machine in 1903, they could obtain very valuable matter which would do the Society an enormous amount of good if it could publish the tables and experiments in the JOURNAL.
>
> "Both Ogilvie and myself have seen the original tables made up by the Wright Brothers from their experiments prior to the building of the machine, and these tables they use today, and although it is the intention of the Brothers Wright to publish a description of their experiments and the information they acquired, the probability is that their lives will be too busy to permit of their having sufficient leisure to do this work."

A few days later, acting on Brewer's suggestion, Major-General Ruck, Chairman of the Council of the Society, wrote and offered on behalf of the Council to

publish all the information about their experiments and added,

"The Council recognise that even the collection of the data of your experiments would entail some considerable work on your part, and they are anxious to put every facility in your way for the collection of such data. They would, therefore, be glad to send a delegate to Dayton, Ohio, where copies of your work could be made and photographs of your work could be taken, and in this way you could be relieved of a great portion of the trouble to which you would otherwise be put."

Ruck added that Griffith Brewer had offered to act as delegate on behalf of the Society.

Most unhappily, within a few weeks of the sending of that letter, Wilbur Wright died, and it was not until the following August that Orville wrote to Griffith Brewer,

"As to the publication of the tables and other scientific data which Wilbur and I collected in the early years of experimenting, I do not think it would be good policy for us to publish them until after we secure a patent adjudication. At the present time it is the possession of this information which keeps our Company at the head of aeronautical work in America, and it is the only advantage we possess over our competitors until we are able to enjoin others from the infringements of our patents by law. I would be glad if you would explain this matter to the member of the Aeronautical Society that wrote to Wilbur and me about the same time as your letter. I have not been able to locate these two letters, so that I could answer them directly."

Griffith Brewer, in his lecture in 1916 on the "Life and Work of Wilbur Wright," repeated that he had examined the wind tunnel and aerofoils and had access to Orville Wright's diary: and Ogilvie, in his Wilbur Wright Memorial Lecture for 1922, stated that he had not only seen the wind tunnel and model aerofoils but "I have been given by Wilbur and Orville Wright hundreds of aerodynamic figures of all kinds—speeds, climbs, and propeller revolutions, etc.—and have never known the estimated figure to have been more than one per cent. or 2 per cent. out from the measured result": but it was not until the delivery of the Wilbur Wright Memorial Lecture on May 25 1939 that fuller details became available of the way that the two brothers had obtained the data which they continued to use, up to the time of Wilbur's death, in their design work and it was not until December 1953 that the full data became available*.

The lecture was given by George Lewis, Chairman of the National Advisory Committee for Aeronautics of the United States, on "Some modern methods of Research in problems in flight."

There were many who still thought, even at that late date, that the brothers had been lucky in their gliding experiments and lucky to have been born at the right moment in the right place and not to have been killed, and in any case scientific and engineering methods obviously hadn't much to do with their success any way, for after all they only made bicycles.

Dr. Lewis's lecture is freely quoted from to help with the answer.

"Figure (16)," said Dr. Lewis, "shows two views of a replica of the original Wright Brothers wind tunnel. The propeller was mounted to run in the circular ring just upstream of the straightening vanes. The tunnel itself was 5 feet long, and the test section was square in elevation, being 22 inches on a side. The speed was about 27 m.p.h., 40 ft. per second.

"Figure (17) is a reproduction of, I quote Orville Wright, 'The original plottings (made December 1901) giving the profile and plan form of the airfoils measured in the wind tunnel in 1901.' In this figure I wish to invite your attention particularly to models 7, 8, 9 and models 10, 11, 12. Here is shown the test programme for the first investigation conducted in the United States on a systematic series of aerofoils. Models 7, 8 and 9, it will be noted, are circular arc plates with systematically varied camber; models 10, 11 and 12 have the same amount of camber in a more forward location. These models had approximately 1 in. chord and 6 in. span, giving an aspect ratio of 6, now standard for aerofoil tests in most aerodynamic laboratories. Systematic investigations on the effect of plan form, aspect ratio, biplane gap-chord ratio, and some miscellaneous studies were also conducted.

"This is indeed a surprising research programme for the year 1901. I wish to emphasise particularly the broad fundamental point of view it shows. So clear was the Wright Brothers' appreciation of the basic factors in the problem that they included all but one of the important variables that have since concerned us in wing and aerofoil research. In this respect most subsequent research along this line appears mainly to have been in extension and experiment of its basic outline. Since it was never published, the research programme clearly bears the independent approval of eminent research scientists in this field, who have almost universally employed the same method of attack."

Figures 18, 19 show the Lift Measuring Balance and the Drift (drag) measuring machine.

"The question of translating the recorded measurements into forces effective on a full scale machine," continued Dr. Lewis, "is the crux of the whole situation, and in this respect the Wright Brothers revealed not only considerable understanding of mechanics, but an astonishing appreciation of the pitfalls involved in small scale wind tunnel testing. . . .

"Orville Wright has given me a verbal description of the whole process,* which, unfortunately, I must reproduce in my own words. The lift was balanced

* *See The Papers of Wilbur and Orville Wright* in the Review pages of this JOURNAL.

* This is the only known description of the wind tunnel balance for measuring drag.

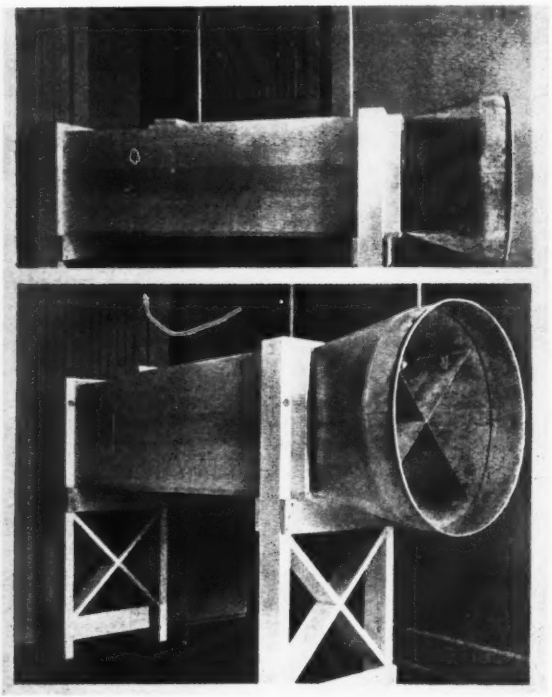


FIGURE 16. Replica of the Wright Wind Tunnel of 1901.

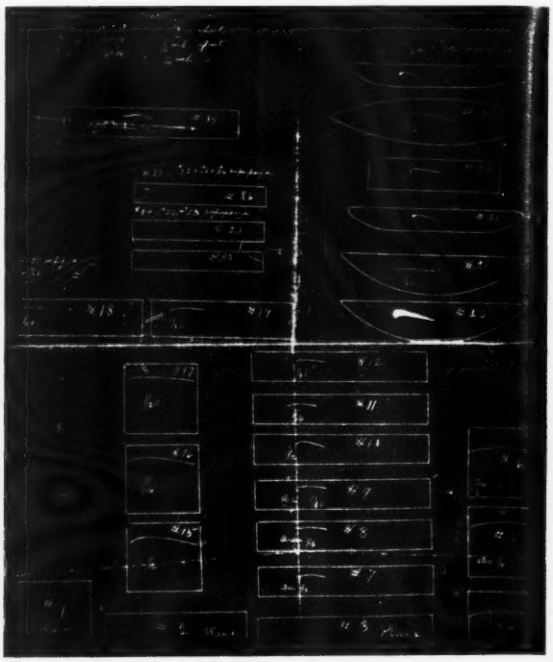


FIGURE 17. Original plottings giving the profile and plan form of some of the aerofoils measured in the Wright Wind Tunnel in 1901.

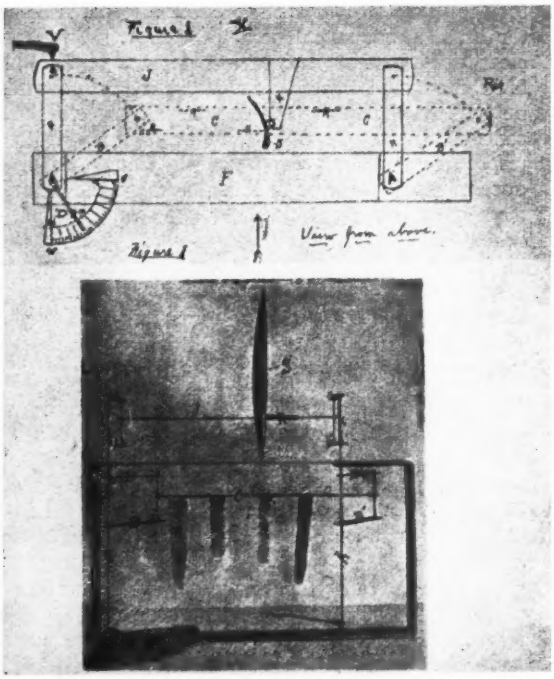


FIGURE 18. Lift measuring instrument for the Wright Wind Tunnel, 1901.

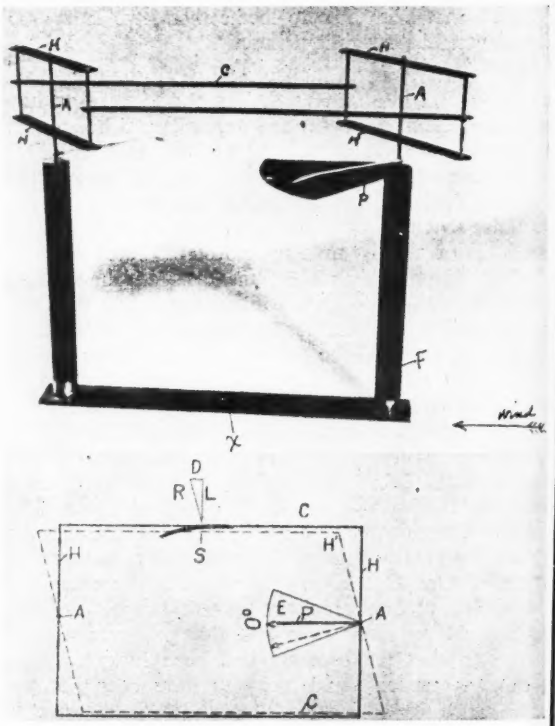


FIGURE 19. Drag/Lift measuring instrument for the Wright Wind Tunnel, 1901.

directly against a set of resistance plates which had previously been calibrated against the drag of a square flat plate of known area in the same position in the airstream as the wings to be investigated.

"The drift was measured in per cent. of the lift. Thus far the steps taken were mainly to obviate difficulties resulting from non-uniform and non-constant velocity in the air stream, though care had previously been taken to reduce these to a minimum. Still, however, no direct measurement of actual forces to be expected on the full-sized wings was available. This was accomplished by the use of a glider tested in 1902. This glider had a wing scaled up from one of the models tested in the wind tunnel and by means of glide tests in winds of known velocity it was possible to determine the lift and drag as actual forces. These tests in effect calibrated one of the wings tested in the wind tunnel for full scale conditions, and since the relation of the other wings to this wing was known from the wind tunnel measurements the characteristics to be expected from all the wings when flown full size were directly indicated by the wind tunnel data.

"This description from Orville Wright reveals, I believe, one aspect of the Wright Brothers research work that has never been realised before—the fact that they adopted an expedient in the year 1901 that automatically corrected measurements at small Reynolds number to the Reynolds number encountered in flight. By the step described they reduced the critical assumptions to one! That the order of merit of the aerofoils would not be seriously affected by Reynolds number, although the absolute values of the coefficients might change. It was not until about thirty years later that aerodynamic research settled this question and showed that at least for a number of critical aerodynamic characteristics the assumption was valid.

"One other point of interest in this connection deserves note. Using the average flight measurements on their 1902 glider and the wind tunnel results on models, the Wright Brothers calculated that the unit drag of a square flat plate of large area was equal to the square of the speed in miles per hour multiplied by the coefficient 0·0033. At the time, Orville Wright has told me, they had their choice among figures varying from 0·0025 to 0·0055 based on tables by other investigators. Much subsequent research has led to the general adoption of the figure 0·00328 for the coefficient in question; truly an astonishing agreement with the value reached by the Wright Brothers through averaging a series of results obtained in flight measurements on a glider in the year 1902. . . . With this information it is amply evident that the Wright Brothers through their investigations in 1901 gained a clear physical conception of the behaviour of wings on which to base the design of their successful 'flying machine.'"

It is interesting to quote from a letter Griffith Brewer wrote to Orville Wright following the lecture by Dr. Lewis.

> "I am sending you the advance proof of the 27th Wilbur Wright Memorial Lecture by Dr. Lewis. I only saw this on the day the lecture was delivered and you can imagine how pleased I was to see the first nine pages devoted to your early work—this seems to me most satisfactory. If we go on like this, extracting information step-by-step, there will be less need for the book which is nearly thirty years overdue."

A great deal of information about the years 1900-1903 and the research work carried out by the Wrights was, indeed, first released through the medium of a Wilbur Wright Memorial Lecture.

More than 200 aerofoils were tested at angles of 0, 2½, 5, 7½, 10, 12½, 15, 17½, 20, 25, 30, 40 and 45 degrees, involving the taking of several thousand readings. The whole of these readings were made in a little more than two months. Those months of aerodynamic research raise the stature of the brothers far above the majority of those seekers after the mystery of flight who came before them, and are an inspiring example of the simple methods which are so characteristic of pioneering genius. The ultimate value of research is not to be measured in terms of the millions voted.

By the beginning of December 1901 the brothers were satisfied that they had obtained sufficient data and experience from their experiments and their gliding experiences in 1900 and 1901 to be able to build a third glider which should prove more efficient than their first two, as well as enabling them to test at full scale some of their model results.

In the new glider, which was to prove so important for their final success, the Wrights increased the aspect ratio to 6 and the area to 305 sq. ft. The area of the front elevator was 15 sq. ft. and that of the two rear fixed vertical surfaces a little over 11½ sq. ft. The weight was 116½ lb. Including the pilot the total weight was reckoned as between 250 and 260 lb.

The brothers made their first test at the end of September 1902, at Kitty Hawk, by flying their new glider as a kite. The flight was successful, but a day or two later Orville Wright while gliding, found one wing rising rapidly. Before he could right himself "the machine came to a stop and started backward. . . . From a height of nearly thirty feet the machine sailed diagonally backward till it struck the ground," said Wilbur who was watching, and afterwards described what had happened.

> "The unlucky aeronaut had time for one hasty glance behind him and the next instant found himself the centre of a mass of fluttering wreckage. How he escaped injury I do not know. . . . This little misadventure which occurred almost at the very beginning of our practice with the new machine was the only thing approaching an accident that happened during these experiments, and was the only occasion on which the machine suffered any injury. The latter was made as good as new by a few days' labour, and was not broken again in any of the many hundred glides we subsequently made with it."

Orville Wright had escaped from the stall which had killed many pioneers.

Stalling accidents in those pioneering days which followed the first flight were a serious cause of concern among flyers. It is not generally known that Orville Wright deliberately stalled a machine to find out the cause of the danger for the benefit of others.

In 1912, ten years after Orville's escape, and a few months after the death of Wilbur, Griffith Brewer went to stay in Dayton. At the end of November 1912 Brewer wrote to Alec Ogilvie.

> "Orville has been going into the cause of a number of accidents, where for some unexplained cause the machine has suddenly pointed downwards and has not been corrected before coming into contact with the ground. This type of accident has occurred in several cases after gliding down from a considerable height and after being straightened out at perhaps 50 ft. from the ground, the machine is seen to turn downward and to continue to turn down until it strikes the ground.
>
> "In some instances, such accidents have been attributed to the fouling of control wires, but in an inquest held by the American authorities on the wreck of an army machine, the control wires were found to be intact.
>
> "The conclusion that Orville came to, is that these accidents are caused by the stalling of the machine and he has been making experiments in the air in order to test the effect of stalling in actual practice. He went to a height of 300 ft. and stalled the machine, and as he had expected, the machine turned slowly downward and for a period of at least 5 or 6 seconds after first stalling, the elevator tail was useless and the moving of the lever had no effect on the inclination of the machine whatever. The machine pointed downward at a very steep angle, possibly 60 degrees before it had gathered sufficient speed to bring it under control. Instead of dropping fifty or sixty feet in this recovery, however, he dropped about 200 feet before he could straighten her out, and he says that he did not stall her in the worst position possible, and he would not be surprised if it would be necessary in some instances to have 300 ft. clear below, to enable the stalling to be corrected in time to save a smash. I will show this letter to Orville before posting it to you so that should you think this experiment of value for the general safety of flyers in England, you are free to give the information."

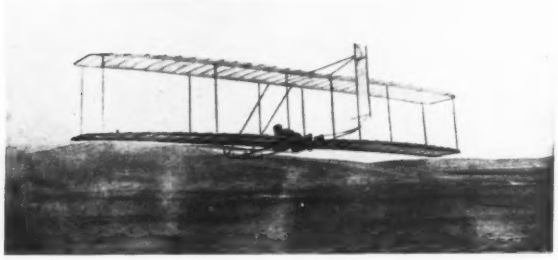


FIGURE 20. 1902 glider at Kill Devil Hill.

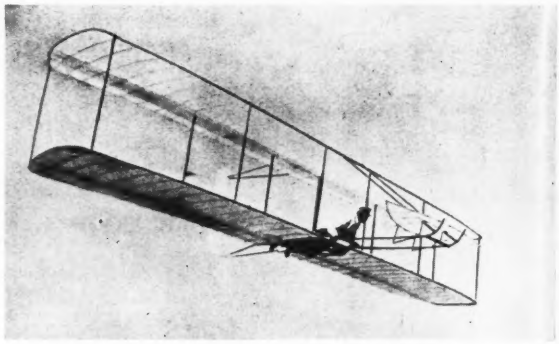


FIGURE 21. High glide by Wilbur Wright, 1902.

In 1934, over thirty years later, Professor B. Melvill Jones gave the 22nd Wilbur Wright Memorial Lecture. The title of that outstanding lecture by an outstanding man was just the single significant word "Stalling." It was the third time he had lectured on this fundamental aerodynamic problem of flight.

> "No subject could be more appropriate to an address in memory of Wilbur Wright, and were it not that until the stall is thoroughly understood and its attendant dangers pushed out of the way, aviation will not be free to play the great rôle which it is undoubtedly destined to play in the civilisation of the world. . . . (Melvill Jones himself did more to push the stall out of the way than any man).
>
> "The Wrights began with a careful study of all previous records of attempted flight and this study suggested to them that some form of hitherto unsuspected trap might be responsible for the seemingly inevitable fatalities which had closed each attempt. They therefore decided never to leave the ground by more than a few feet until they had discovered what the trap could be, and it is, I think, the day on which this decision was made that more than any other marks the beginning of the modern era of flight. All honour to the Wrights, that by forethought they avoided the pitfall which had hitherto barred the way to progress and so survived to hand their knowledge on. Had they also fallen into the trap, it is possible that the mysterious deaths of a few more pioneers would have confirmed the universal view that attempted flight meant suicide, and interest might have again elapsed for a long period.
>
> "What did the Wrights discover about the stall? Simply that at low speeds either wing is liable to start a sudden downward and rearward movement, which, if unchecked, results in a spinning dive to earth. They countered this by interconnecting rudder and warp (the equivalent of aileron) so that either wing could be pushed upwards and forwards by a single movement of the controls. Though we do not now use their method of interconnecting the controls, yet, after a vast amount of research, we still aim at achieving the same result: to force the wing tip upwards and forwards. These considerations, I think, justify my opening remark that the subject I have chosen is peculiarly appropriate to a lecture in memory of Wilbur Wright."

The brothers, after the crash, decided to substitute a single vertical movable surface of only 6 sq. ft. area against the original two fixed surfaces and to interconnect with it the warping wing tip mechanism.

"We now had the structure in the form pictured and described in the drawings and specification of our patent," said Wilbur Wright, in evidence in a patent action some years later. "With this apparatus we made nearly 700 glides in the two or three weeks following. We flew it in calms and we flew it in winds as high as 35 miles an hour. We steered it to right or left, and performed all the evolutions necessary for flight."

The two brothers left Kitty Hawk that year in a very different mood from that of the previous year. They had been gliding in winds up to 36 miles an hour, and had made longer glides than had ever been done before, with their glider under full control. They had had more practice in the air than any experimenters before them, and were confident that the next step only consisted in fitting an engine and making controlled power flights.

In the last six days at Kitty Hawk they made more than 375 glides, the longest of which was 622 ft., lasting 26 seconds.

Everything was now ready for the supreme test, that of a power-driven aeroplane under control.

The Year of Destiny, 1903

"To stretch the octave 'twixt the dream and the deed, ah, that's the thrill!"

Richard le Gallienne.

Seldom, in the history of aeronautics, can any designer have faced the dawn of the first full scale trial of his avianlike creation with greater confidence of success than did Wilbur and Orville Wright. And not without cause and reason.

"It is beneficial," said Hugh Dryden, Director of of Research for the N.A.C.A., in his Wilbur Wright Memorial Lecture of 1949 on "The Aeronautical Research Scene, Goals, Methods, and Accomplishments," "to aeronautical scientists and engineers to be reminded periodically that Wilbur and Orville Wright achieved success as a result of keen intellectual effort and hard work, and not by some chance inspiration. They devised new instruments of research; they conducted extensive experimental programmes in wind tunnel and flight; they studied problems of aerodynamics, thermodynamics, and structural design; they applied the results to the design of a practical aeroplane; and they had the immense satisfaction of successful flight."

As the abiding genius of the two brothers becomes yearly more apparent and knowledge of what their real achievement was, then so, and so rightly, is tribute paid by the great research workers, scientists, and engineers in the present day fields of aeronautics.

That winter and the spring of 1903, following their successful gliding experiments, the two brothers began that work which, in but twelve short months, during which time they had to supervise their own cycle business, was to "fill the speaking trump of future fame."

Their first problem was the one which ever faces aircraft designers—the aircraft engine.

"Immediately upon our return to Dayton," said Orville Wright, "we wrote, stating the purpose for which we desired the motor, and asking whether they could furnish one that would develop eight brake horse power, with a weight complete not exceeding 200 lb. Most of the companies answered that they were too busy with their regular business."

It was a polite way of intimating that the companies did not want to become a laughing stock by being mixed up in such a crazy thing as flying.

These two remarkable cycle manufacturers, with a sound general education, but only an elementary technical one, decided to design their own engine, an engine upon which their very lives might depend. They had built one gas engine, of 5 in. bore and 7 in. stroke, to run the machinery of their cycle shop, but that was all their experience of engines, and it did not matter if that one broke down occasionally at unexpected moments.

The brothers estimated that the weight of their aeroplane would be round about 625 lb., including pilot, and the minimum horsepower required would be just over 8. They calculated that they could build an engine developing that power for the 200 lb. weight allowed, including all accessories, and decided on one of four cylinders, each with a four inch bore and a four inch stroke.

"To be certain that four cylinders of the size we adopted would develop the necessary horsepower, we first fitted them into a temporary frame. . . . In just six weeks from the design was started, we had the motor on the block testing its power. The ability to do this so quickly was largely due to the enthusiastic and efficient services of Mr. C. E. Taylor, who did all the machine work in our shop for the first as well as the succeeding experimental machines."

The engine could only be run for a minute or two at a time, as no provision had been made for the lubrication of cylinders or bearings during the test! The engine developed 9 brake horsepower and the Wrights were satisfied that when lubricated it would develop still greater power. When ready it actually developed 16 brake horsepower for a few seconds and it settled down to 12 h.p., well above the estimate of 8 h.p. they had considered sufficient. It weighed about 170 lb.

There were no propeller designers to help the Wrights and they had no idea how a propeller should

N° 6732 A.D. 1904

(Under International Convention.)

Date claimed for Patent under Patents Act, 1901, being date of first Foreign Application (in United States), 23rd Mar., 1903

Date of Application (in the United Kingdom), 19th Mar., 1904

Accepted, 12th May, 1904

COMPLETE SPECIFICATION.

Improvements in Aeronautical Machines.

We, ORVILLE WRIGHT and WILBUR WRIGHT, both of 1127 W. Third Street, Dayton, County of Montgomery, State of Ohio, United States of America, Manufacturers, do hereby declare the nature of our invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our invention relates to improvements in that class of aeronautical machines in which the weight is sustained by the reactions resulting when thin surfaces, or wings, are moved horizontally almost edgewise through the air at a small angle of incidence, either by the application of mechanical power, or by the utilization of the force of gravity.

The objects of our invention are, first, to provide a structure combining lightness, strength, convenience of construction, and the least possible edge resistance; second, to provide means for maintaining or restoring the equilibrium of the apparatus; and third, to provide efficient means of guiding the machine in both vertical and horizontal directions. We obtain these objects by the mechanism shown in the accompanying drawing, in which Fig. 1 is a view in perspective of the machine, Fig. 2 a side elevation, and Fig. 3 a top plan view.

The superposed horizontal surfaces 1, formed by stretching cloth upon frames of wood and wire, constitute the "wings," or supporting part of the apparatus. They are connected to each other through hinge joints by the upright standards 2 and the lateral stay wires 3, which together with the lateral spars 4 of the wing framing, form truss systems giving the whole machine great transverse rigidity and strength. The hinge joints admit of both flexing and twisting movements, and may be either ball and socket joints, or any joint of sufficiently loose construction to admit of the movements specified. The object of joints having both flexing and twisting movements is to permit superposed wing surfaces, or parts thereof, when joined together by upright standards, to be twisted or bent out of their normal planes for the purpose hereafter specified. We do not restrict ourselves to the use of any particular form of joint, nor to its use at any particular number of places.

One end of the rope 5 is attached near the rear corner of the upper surface, passes diagonally downward around the pulleys 6, and diagonally upward to the corresponding corner at the opposite end of the machine. The rope 8 is attached to the front corner of the upper surface, passes around the pulleys 7 and back to the opposite upper corner. The movable cradle 9 is attached to

[*Price* 8*d.*]

FIGURE 22. First page of British Patent No. 6732 and *(on the facing page)* the Illustrations of Patent No. 6732.

A.D. 1904. March 19. № 6732.

WRIGHT & *another's* Complete Specification. [1 SHEET]

[This Drawing is a reproduction of the Original on a reduced scale.]

(3rd Edition)

Fig. 1.

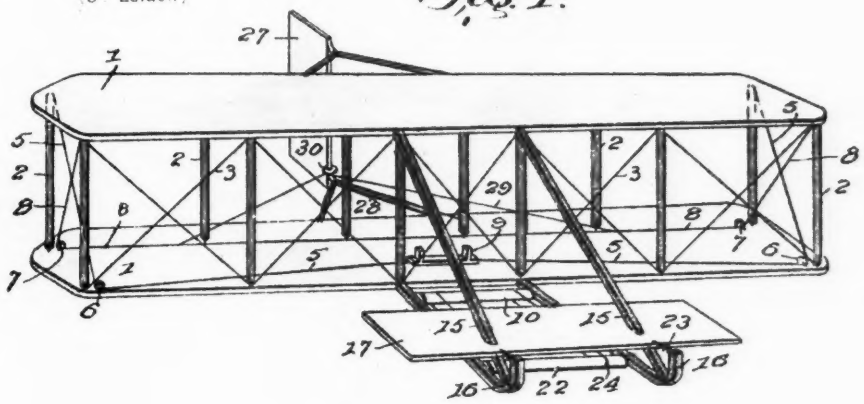


Fig. 2.

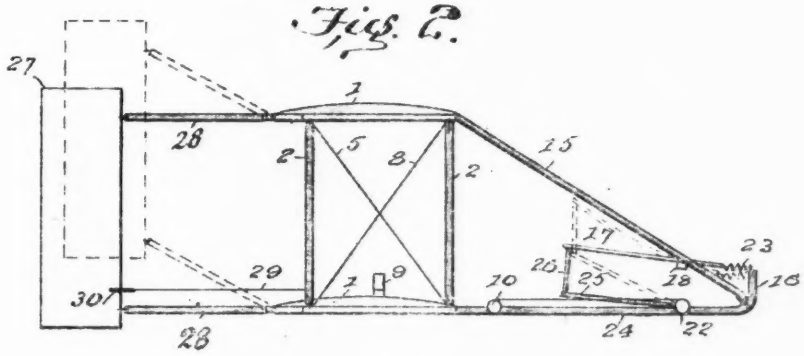
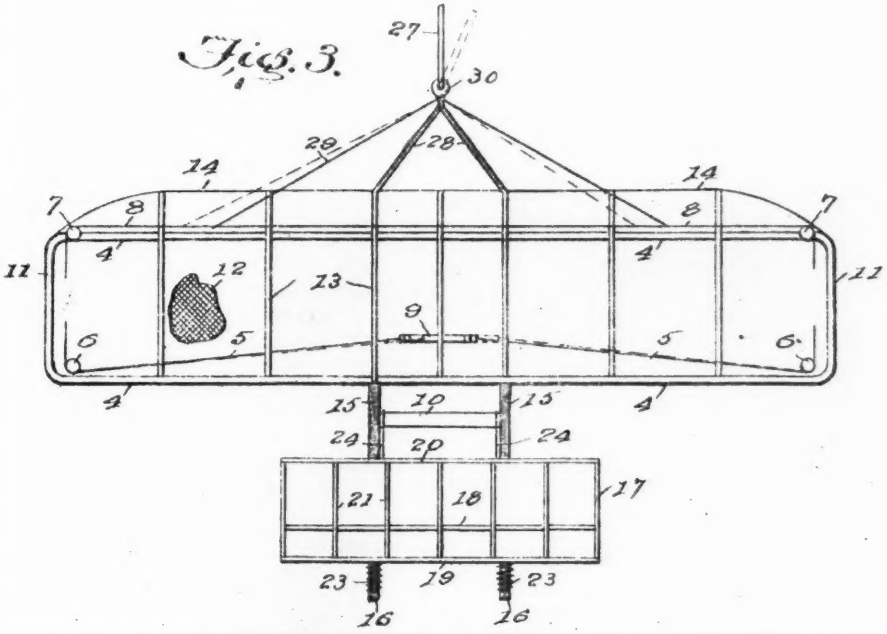


Fig. 3.



Malby & Sons Photo-Litho

be designed. They borrowed from the Dayton Public Library what books they found available on the subject of marine propellers, believing that all they had to do was to substitute the necessary constants for air and water, to get the answers they wanted. But all the marine formulæ were empirical and could not be adapted.

These remarkable men argued that a propeller was nothing more than an aeroplane travelling in a spiral track, and as they had been able to calculate what happened when an aeroplane flew on a straight course, what was more simple than calculating it for a spiral course?

Of such stuff is genius made!

The two spent long hours discussing the problem which faced them, one which must be solved before they attempted to fly. Out of their arguments, at long last, an understanding was slowly reached of what really happened when an aeroplane moved forward under the thrust of a propeller moving round. Both realised that the stationary thrust gave them little indication of what happened in the air, and that, ultimately, the only real test of efficiency was to fly.

Two propellers were decided upon, so that a larger pitch could be used and a larger volume of air could be acted upon than with only one propeller. By arranging them to revolve in opposite directions their gyroscopic effects were neutralised. The motor was mounted beside the pilot (who was prone on the wing), so that in case of a nose dive the engine would not fall on him. The general construction of the aeroplane followed that of the successful 1902 glider. With the increase of horsepower from 8 to 12 the weight of the aeroplane and pilot was increased to between 750 and 800 lb. The wing area was 510 sq. ft. Tests were carried out on the chain drive and shafting before the brothers were satisfied that they could go to Kitty Hawk.

They arrived at the end of September to find the building they had erected and used in 1901 and 1902 had been blown down by storms and the first task was to repair and re-erect it. The weather turned out, too, to be stormy, but when they were able both brothers practised gliding in between the storms and building the first aeroplane and fitting the engine.

It is interesting to note that during that time Octave Chanute visited the camp and discussed the calculations upon which the Wrights based their hopes of success. He told them that the loss for transmission of power should be taken as 25 to 30 per cent., more than twice as much as the Wrights had allowed for the chain drives from the engine to the propellers. The brothers waited until Chanute had left the camp and then made their own test. They were familiar with the friction of cycle chains and were greatly disturbed by Chanute's figures. The test was simple and effective. One of their chains was suspended over a sprocket and bags of sand were hung on each side whose weight represented as near as possible the estimated thrust of the propellers. The additional weight on either side necessary to start the chain moving gave them a measure of the frictional loss they might expect. The test confirmed the brothers' calculations as being correct.

Bad weather held up for several weeks any attempt to fly, during which time the brothers designed a means for automatically measuring the duration, the distance travelled and the number of revolutions of the engine during the flights they were going to make. All this because they wanted to have some full scale data on propellers to test the accuracy of their calculations, for future design work.

Further delay came when a tubular propeller shaft cracked for the second time while another test was being carried out on the engine. It was not until December 11 1903 that Orville was able to get back from Dayton with a new solid steel shafting which was more elastic than tubular shafting. Three days later the first attempt at flight was made, with Wilbur as the pilot, from one of the sand hills. The aeroplane went off so quickly that it rose too sharply and stalled. A broken skid and other damage took a couple of days to repair.

The Wrights paid more attention to the aerodynamical problems than the structural problems, as the latter were comparatively well-known and to a large extent solved, while the former were not. Nevertheless they took considerable care to safeguard their aeroplane structure from breaking up in the air.

Professor N. J. Hoff in the Forty-first Wilbur Wright Memorial Lecture on " Buckling and Stability," read on September 14 1953, paid special tribute to the way the brothers tested their structure, quoting at length from the Wright Papers, not then published, in the Library of Congress*.

" The Wrights were most careful in selecting and testing the materials of construction," said Hoff, " and considered dynamic tests as important as static tests. On 6th September 1917 Orville Wright wrote to Thomas R. C. Wilson:

" ' In 1901, 1902 and 1903 we made a number of tests upon Eastern spruce and white pine. The spruces when kiln dried by the processes of that day were very inferior to the air-dried. The white pine did not seem to suffer so much in the dry kiln. The shock tests indicated that the spruce was superior to clear white pine. But the superiority of the spruce was more apparent in practical use in the machines.'

" On 23rd September 1900 Wilbur Wright tried to convince his father, the Reverend Milton Wright, that he was taking the necessary precautions to ensure that their glider was safe structurally:

" ' I am constructing my machine to sustain about five times my weight (700 lb. plus?) and am testing every piece,' he wrote.

" Regarding the strength tests of the complete aeroplane one may refer to an entry in Orville Wright's diary made on 16th November 1903:

" ' We hung the machine on tips to test strength. The cloth wrinkled badly, necessitating a change in the trussing of the tips so that the strain be more evenly carried by front and rear spars and uprights. This requires a change in the controlling wires which will have to be operated at the rear. The uprights stood test of twice what will be required of them

* Some of these papers were published in December 1953.

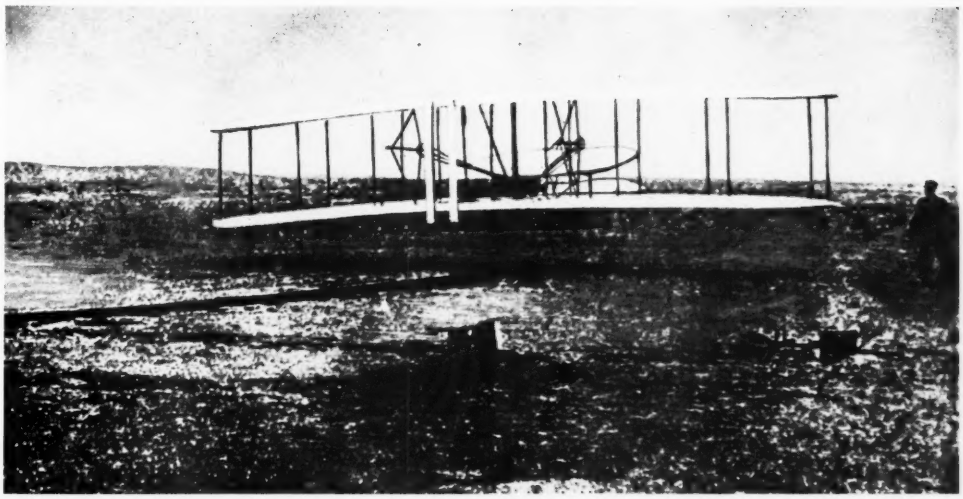


FIGURE 23. The first flight, December 17 1903. Orville Wright at the controls, Wilbur Wright near wing tip. The machine has just left the track.

even though the wire connecting their centers had not been put in yet.'

" An entry on 17th November 1903, reads:

" ' Worked today on changing wires and in putting on wire to connect centers of front uprights. Supported at tips machine stood test of 440 lb. at center without any signs of being overburdened.'

" Finally one might quote from a letter Wilbur Wright wrote just two weeks before the first successful human flight in a powered heavier-than-air machine. The letter is addressed to George A. Spratt and is dated 2nd December 1903 from Kill Devil Hills:

" ' We have not tried to glide the big machine yet, and probably shall not this year, as favorable days are very scarce now. We hung it on its wing tips some days ago and loaded the front set of trussing to more than six times its regular strain in the air. We also hung it by the tips and ran the engine screws with the man also on board. The strength of the machine seems ' O.K.' ' "

How narrow is the road between disaster and success!

Delays had brought severe winter weather to make success seem far away on those dreary, deserted sand wastes, and failure more than likely if the brothers attempted flying under such conditions. A bitter cold wind blew during the whole of the night of December 16 1903, and the rain-filled pools in the sand, on the following morning of the 17th, were covered with ice. The wind was reaching 25 to 27 miles an hour and as it showed no signs of abating by the middle of the morning, it was decided to risk an attempt at a flight. The cold northerly wind was so biting that they were compelled to return at intervals to their building to unfreeze before the fire they had taken the precaution to build up.

An agreed signal had been made, which could be seen from the Kill Devil Life Saving Station just over a mile away, to announce that the brothers were attempting to fly, so that those who wished could come to see the first flight. By the time everything was ready only five people stood " upon the threshold of the new," J. T. Daniels, W. S. Dough and A. D. Etheridge from the Life Saving Station; W. C. Brinkley of Manteo, and a boy Johnny Moore.

Writing on the tenth anniversary of that day, Orville Wright said, " With all the knowledge and skill acquired in thousands of flights in the last ten years, I would hardly think today of making my first flight on a strange machine in a twenty-seven-mile wind, even if I knew that the machine had already flown and was safe."

But in the beginnings of most great adventures of the body and soul, there is an abiding faith which is not shattered by adversity. The Wrights had that faith which moves mountains.

For two or three minutes their home-designed engine was run to warm it up. With Orville as pilot and Wilbur at one wing tip to help to keep the machine level as it ran down the track into the wind, the machine rose slowly, erratically, flew for twelve seconds and landed. Wilbur followed with a flight of eleven seconds and an hour after the first flight Orville again flew, this time for fifteen seconds. The last flight was made by Wilbur just after mid-day. It lasted 59 seconds and the aeroplane covered a measured distance of 852 feet.

In all the flights the two men found the front elevator extremely sensitive, with the result that the path of the machine was an undulating one, a pitching up and down. In the last flight Wilbur Wright had kept control over the greater part of the distance and maintained steady, level flight, but the pitching began again in the last fifty feet or so. All the flights had been made as close to the ground as possible, leaving little room to manœuvre. It was during one of the pitching downward movements that the front elevator support struck the sand, before Wilbur Wright could react, and was broken.

All possibilities of any further flights were destroyed for that year by a sudden gust of wind, which struck the machine as the brothers were discussing the flight, and began to turn it over, breaking some of the wing structure, bending the chain guides and damaging the engine.

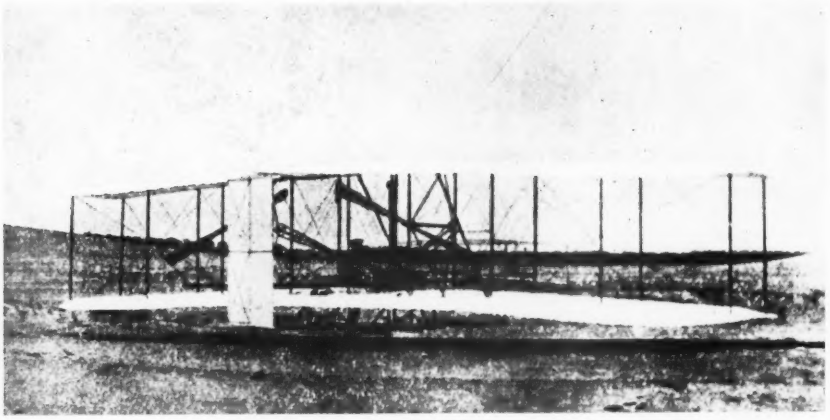


FIGURE 24. View showing the vertical rudders of the first aeroplane, taken at Kitty Hawk.

That afternoon Orville Wright telegraphed to his father.

> "Success four flights Thursday morning all against twenty-one mile wind started from level with engine power alone average speed through air thirty-one miles longest 59 seconds inform press home Christmas."*

The telegraph operator in Norfolk who received the telegram from Kitty Hawk, told a local news reporter who, unable to get in touch with the Wrights, wrote a fantastic and inaccurate account of what had happened, and this appeared in the *Virginian Pilot* the following morning. From this reporter at Norfolk, various papers got the garbled imaginative account and when, in the first week of January 1904, the Wrights sent out a statement of what actually happened, the truth was unable to overtake the original story.

On January 6 1904, Orville Wright wrote to Major Baden-Powell, President of the Aeronautical Society of Great Britain, and enclosed a copy of the statement. It was printed in the first quarterly issue of the JOURNAL after its receipt. It is given in facsimile in Figs. 26 and 27.

The news was announced by Baden-Powell at a lecture meeting of the Society held at the Society of Arts on March 17 1904.

> "Most of you know about the Brothers Wright and the experiments they have been making in America, how they have been making some very good glides, and how just lately they have applied a motor to their machine and made some very successful experiments in rising off the ground into the air. Although some of the newspaper accounts were much exaggerated there is still no doubt that some of the experiments were very satisfactory, and are amongst the most satisfactory ever made in human flight. I believe it is quite untrue that they travelled anything like three miles, because it was the very first trial of a new machine, and they did not think it worth making any prolonged flight."

* In a letter to Chanute on December 28 1903 Wilbur Wright wrote: "One of the most gratifying features of the trials was the fact that all our calculations were shown to have worked out with absolute exactness as far as we can see, though we have not yet made our final computations on the performance of the machine."

The news could not have come entirely as a surprise to the President in view of the letter he had received from Chanute and quoted in his Presidential address to the Society in December 1902. Many members of the Society were well aware of the gliding experiments of the Wrights and eagerly awaited further news. Patrick Alexander, who was a friend of everybody in British aviation and of many on the Continent, a member of the Society to which he had shown a constant generosity, had been introduced to the Wrights in America. On September 19 1903, just three months before he flew, Wilbur Wright wrote to Chanute, "We were glad to learn that Mr. Alexander is thinking of visiting this country again . . . if Mr. Alexander's trip should occur at a time that would make it at all practicable to invite him to camp we shall certainly do so, as we were much pleased with him so far as his brief visit last year enabled us to make his acquaintance. We both liked him very much."

It is not given to man to see into the future, for otherwise it is certain one member of the Society would have been at Kitty Hawk on December 17 1903, one whom the Wrights "both liked very much," as did all of us who knew Patrick Alexander.

Octave Chanute himself had visited London in the Spring of 1903 and had seen Stuart Bruce, the Honorary Secretary of the Society, to whom he gave an account of the work of the Wrights first-hand and with whom he left a number of photographs of the gliders.

Baden-Powell, at the meeting of the Society held on March 24 1903, had again referred to the work of the Wrights, showing the keen interest he was taking. C. A. Alderson, another member, gave a lecture on flying machines to the Aeronautical Institute* a month later, a lecture at which Chanute was present, and during which he gave particulars of the Wrights' work.

In the course of a review in the JOURNAL for July 1904, of Chanute's paper on Aerial Navigation read before the American Association for the Advancement of Science, the reviewer (I suspect Baden-Powell) said:

> "In the course of Mr. Chanute's remarks about flying machines he mentions that the data for the full

* The Aeronautical Institute and Club was formed in 1903 but did not survive.

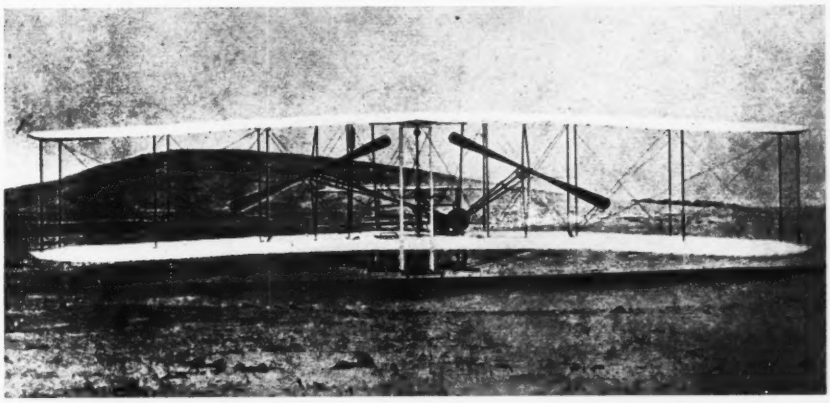


FIGURE 25. Rear view of the first aeroplane, taken at Kitty Hawk.

sized flying machine of Professor Langley, which was tested October 7 and December 5, have not been published. From newspaper photographs it appears to be an amplification of the models which flew successfully in 1896, and this would necessarily make it very frail. He thinks the failure must have been caused by the landing gear, and does not prove this machine is worthless. Like the failures of others, it indicates better design must be sought for, and that the first requisites are that the machine shall be stable in the air, shall be quite under the control of its operator, who should learn to manage the machine before flying it. This latter remark may seem to be paradoxical, but it was the kind of practical efficiency acquired by the Brothers Wright, whose flying machine was successfully tested on December 17. For three years they experimented with gliding machines and it was only after they had obtained thorough command of their movements in the air that they ventured to add a motor. Mr. Chanute considers that too much praise cannot be awarded to these gentlemen.

"'Being accomplished mechanics,' said Chanute, 'they designed and built their apparatus, applying thereto a new and effective mode of control of their own. They learnt its use at considerable personal risk of accident. They planned and built the motor, having found none in the market they deemed suitable. They evolved a novel and superior form of propeller; and all this was done with their own hands, without financial help from anybody.'"

In the very early days of their experiments, on October 24 1901, Wilbur wrote to his father, "Mr. Chanute has several times kindly offered to help bear the expense of these experiments but we have refused to accept money because we would be led to neglect our regular business too much if the expense of experimenting did not exercise a salutary effect on the time devoted to them."

The expense of experimenting has grown in the last fifty years, but it seems to have failed to exercise a salutary effect on anybody.

It is certain that the remarkable triumph of the two brothers would not have been made by either of them singly. All those who knew them well emphasised that no steps forward in those astonishing years of gliding experiments and the successful power flights which followed, were taken by either alone. Griffith Brewer and Alec Ogilvie, who spent considerable time with both men in work and play, both commented on the remarkable and unique mental relationship there was between the brothers. Each brother argued against the other in turn until both had arrived at an agreed conclusion, though both in the course of their discussions might change the viewpoints they had at the beginning. At the finish, however, their understanding was complete.

A new idea might originate with either and the carrying of it out did not depend particularly upon the ability of one or the other. A single example, out of many, of their working may be cited here. It was Orville who first suggested that the two wings should be at different angles of attack in a turn, and Wilbur who hit upon the way to warp the wings to obtain the desired result.

Years of Recognition 1904 - 1913

"Two immortal lights
Rise slowly up into the sky
To shine there everlastingly".
Matthew Arnold.

Wilbur and Orville Wright had a total of but a little over a minute and a half of actual flying when, in January 1904, they began to build a new machine and a new engine. The new machine weighed, with pilot and 70 lb. of iron bars fixed under the front elevator (to bring forward the centre of gravity position), some 900 lb. The brothers obtained the use of a field, known as Huffman Prairie, a few miles from Dayton, as an aerodrome, in order to be near their "maintenance and repair shop."

The experiments made and the results obtained during the years 1904-5 are largely given here in letters from the Wrights and Octave Chanute to members of the Society, who were taking a much livelier interest than was being taken in America at the time.

Wilbur Wright
Orville Wright

Established in 1892

Wright Cycle Company

1127 West Third Street

DAYTON, OHIO, Jan. 7th, 1908.

Major B. F. S. Baden-Powell,

Lonion.

Dear Sir:

As many of the accounts published in the daily papers contain errors and misleading statements, and knowing the interest you take in the subject, I take pleasure in sending you a clipping which gives an authentic account of the recent trials of our successful Flyer.

Respectfully yours,

Orville Wright

Wright Flyer

A Report Of Late Tests

Is Given by Messrs Wright, Inventors of the Machine.

Interesting Description of the Trials Made at Kitty Kawk.

It had not been our intention to make any detailed public statement concerning the private trails of our power "Flyer" on the 17th of December last; but since the contents of a private telegram, announcing to our folks at home the success of our trials, was dishonestly communicated to newspaper men at the Norfolk office, and led to the imposition upon the public by persons who never saw the "Flyer" or its flights, of a fictitious story incorrect in almost every detail; and since this story, together with several pretended interviews or statements, which were fakes pure and simple, have been very widely disseminated, we feel impelled to make some corrections. The real facts were as follows:

FIGURE 26 (*above*) and 27 (*opposite*). Orville Wright's letter to Major Baden-Powell of January 7 1904 and the first part of the newspaper cutting. The rest of the cutting was sent to the printer for the paper reproduced in the JOURNAL April 1904, a facsimile of which is shown on the opposite page ("With the Power Flyer").

A similar newspaper cutting was also sent to Lawrence Hargrave by Wilbur Wright (*see* Fig. 28).

not occur simultaneously or uniformly over the whole surface of the machine, set up other disturbances still more troublesome. A sudden gust, we are told, will strike the front of the machine and throw it up before the back part is acted upon at all. Again, the right wing may meet a wind of very different velocity and trend from the left wing, and in this case the machine tends to turn over sideways. It is the opinion of the experimenters that though the problem of overcoming these disturbances by automatic means has engaged the attention of many ingenious minds, in their opinion it has seemed preferable to depend entirely on intelligence for the control. In all their machines, the maintenance of the equilibrium has been dependent on the skill and constant vigilance of the aviators.

2.—With the Power Flyer.—Communicated by Mr. Orville Wright.

Since the above-mentioned experiments with machines which depend upon gravity for their motive power, the brothers Wright have made successful flights with their power flyer, which is supplied with a motor.

Regarding these latter experiments, fearing lest members of the Aëronautical Society of Great Britain may have been misled by some of the erroneous statements that have appeared in the late accounts of the flights, Mr. Orville Wright has communicated to the Society a true and authentic account of these experiments, which is as follows :—

On the morning of December 17th, between the hours of 10.30 o'clock and noon, four flights were made, two by Mr. Orville Wright and two by Mr. Wilbur Wright. The starts were all made from a point on the levels and about 200 feet west of our camp, which is located a quarter of a mile north of the Kill Devil Sand Hill, in Dare County, North Carolina. The wind at the time of the flights had a velocity of 27 miles an hour at 10 o'clock, and 24 miles an hour at noon, as recorded by the anemometer at the Kitty Hawk weather bureau station. This anemometer is 30 feet from the ground. Our own measurements, made with a hand-anemometer at a height of four feet from the ground, showed a velocity of about 22 miles when the first flight was made, and 20½ miles at the time of the last one. The flights were directly against the wind. Each time the machine started from the level ground by its own power alone, with no assistance from gravity or any other sources whatever. After a run of about 40 feet along a mono-rail track, which held the machine eight inches from the ground, it rose from the track and, under the direction of the operator, climbed upward on an inclined course till a height of 8 or 10 feet from the ground was reached, after which the course was kept as near horizontal as the wind gusts and the limited skill of the operator would permit. Into the teeth of a December gale the "Flyer" made its way forward with a speed of 10 miles an hour over the ground, and 30 to 35 miles an hour through the air. It had previously been decided that, for reasons of personal safety, these first trials should be made as close to the ground as possible. The height chosen was scarcely sufficient for manœuvring in so gusty a wind and with no previous acquaintance with the conduct of the machine and its controlling mechanisms. Consequently the first flight was short. The succeeding flights rapidly increased in length and at the fourth trial a flight of 59 seconds was made, in which time the machine flew a little more than a half mile through the air, and a distance of 852 feet over the ground. The landing was due to a slight error of judgment on the part of the operator. After passing over a little hummock of sand, in attempting to bring the machine down to the desired height, the operator turned the rudder too far, and the machine turned downward more quickly than had been expected. The reverse movement of the rudder was a fraction of a second too late to prevent the machine from touching the ground and thus ending the flight. The whole occurrence occupied little, if any more, than one second of time.

Only those who are acquainted with practical aeronautics can appreciate the difficulties of attempting the first trials of a flying machine in a 25-mile gale. As winter was already well set in, we should have postponed our trials to a more favourable season, but for the fact that we were determined, before returning home, to know whether the machine possessed sufficient power to fly, sufficient strength to withstand the shock of landings, and sufficient capacity of control to make flight safe in boisterous winds, as well as in calm air. When these points had been definitely established, we at once packed our goods and returned home, knowing that the age of the flying machine had come at last.

From the beginning we have employed entirely new principles of control; and as all the experiments have been conducted at our own expense, without assistance from any individual or institution, we do not feel ready at present to give out any pictures or detailed description of the machine.

Dayton, Ohio, Jan. 27, 1904.

Mr. Lawrence Hargrave

Dear Sir,

Your letter of some months ago came while my brother and I were in camp at Kitty Hawk, which is nearly a thousand miles from here. We were there from the latter part of September till almost Christmas time. We continued our experiments with our 1902 gliding machine, giving special attention to attempts at soaring on the face of the hill down hill in a winds of 20 to 30 miles an hour. We frequently stood almost still for a half minute at a time, but so it was necessary at times to move forward a little

(2) ← 1 → (3)

on maneuvering we would after a time pass out of the rising current. As we did not feel it safe to allow the machine to float back again, we were of course compelled to land. The longest flight was one minute and twelve seconds.

Most of our time was taken up with the construction of a machine of 510 sq. ft. on which we mounted a gasoline motor. The total weight of the apparatus was about 600 lbs, and including the operator, 745 lbs. The machine was finished so late in the year that we made only such trials as were necessary to determine whether the machine possessed the power of flight, and a capacity of control such as would make it reasonably safe in operation. As imaginative newspapermen have sent out some very incorrect statements regarding these trials, I take pleasure in sending you a statement which we have ourselves given out. When the warm weather returns we shall try to obtain further practice, and make longer flights.

I presume that this time of year is much more favorable for experimenting on your side of the earth than on this and that we may soon hope to hear

I your further progress.

With kindest regards, in which my brother joins me, I am,

Yours truly
Wilbur Wright.

FIGURE 28. Original of Wilbur Wright's letter of January 28 1904 to Lawrence Hargrave (slightly reduced in size).

On May 9 1904, Chanute wrote to Baden-Powell, "Wright Brothers expect to resume experimenting in about ten days. There will, of course, be many delays and breakages, but I expect them to attain very good results."

The speed of the prevailing wind at Huffman Prairie was lower than that at Kitty Hawk and when the brothers tried to make their first flight with their new machine the wind proved too light for the short take-off necessary in such a comparatively small aerodrome. The machine again failed to rise into the air the following day. Unfortunately, or perhaps fortunately as it turned out, the newspapers in Dayton and Cincinnati, at the invitation of the two brothers, had sent representatives to report the flying. After these two days of disappointment the reporters lost interest and the Wrights gained the freedom from uneasy publicity which they desired in order to carry on with their experiments.

On June 16 1905, A. F. Zahm who, later, played a prominent part in the struggle against the official recognition of the Wrights' work by the Smithsonian Institution in Washington, wrote to E. Stuart Bruce, then the Honorary Secretary of the Society.

"I would like to give you a bit of news," he wrote, "on condition that it be withheld from the papers till you have it from other sources. I have learned that the Wright Brothers have been experimenting at Dayton, Ohio, with much success; but have induced the local reporters to keep still*. They have made 105 flights in a machine carrying one man and 70 lb. of bar iron. The machine is under good control, flies 40 miles an hour, and has made trips of about 3 miles circling about at a height not exceeding 30 or 40 feet. I judge that the 70 pounds of iron can be replaced by gasoline which will enable them to keep on the wing several hours continuously. It is probable that before long you will see an authoritative statement in one or more periodicals. If the above data be true—and I have them from reliable authority—it means that a new epoch in aeronautics is at hand."

In July 1905 Wilbur Wright wrote to Sidney Hollands, a member of the Society who was in fairly regular correspondence with Octave Chanute, as well as with the Wrights:

"We have received your letter with much pleasure.

"Our experiments were continued during a considerable part of the summer and autumn of last year with quite favourable results. It is not our desire, however, that too much interest in our work should be publicly aroused at present, and accordingly can not make any extended report until the experimental period is past. In 1904 we succeeded for the first time in making complete circles and landing at the starting point. On two different occasions the flight extended over nearly three miles. The duration of these flights was five minutes and four seconds in one case, and four minutes and fifty-two seconds in the other. The speed was about 35 miles an hour. The new problems, previously unsuspected, which are met at almost every step, consume much time in developing a machine for practical use, but the critical points have been passed, and within a reasonable time we expect to have the machine ready to present to the world for some serviceable purpose. . . . We have no recent word regarding Prof. Langley, but I think he has abandoned the effort to fly his machine. It was evidently too frail to be of real value for experimental purpose."

It was the comparative smallness of Huffman Prairie, combined with the low speed of the average wind, that led the Wrights to make their famous "assisted take-off" device, a derrick with a falling weight. This weight, 1,600 lb., fell through a height of 16½ feet and by means of ropes and pulleys, exerted a pull of several hundred pounds through a distance of 49 feet. By this means, even in a calm, the machine could be launched in some 50 feet. Over a hundred flights were made in 1904, most of short duration.

On November 17, 1905, Orville Wright wrote to Patrick Alexander giving him an account of what he and his brother had been doing on Huffman Prairie during the year. The letter was read by Alexander at the meeting of the Society held on December 15 1905, at which Baden-Powell was in the Chair.

"We have finished our experiments for this year, after a season of gratifying success. Our field of experiment, which is situated 8 miles east of Dayton, has been very unfavourable for experiment for a great part of the time owing to the nature of the soil and the frequent rains of the past summer*. Up to the 6th September we had flown the machine on but eight different days, testing a number of changes which we had made since 1904, and as a result, the flights on these days were not as long as our best ones of last year. During the month of September, we gradually improved in our practice, and on the 26th made a flight of a little over 11 miles. On the 30th we increased this to 12 and one-fifth miles, on October 3 to fifteen and one-fifth miles, on October 4 to twenty-three and three-fourth miles and on October 5 to twenty-four and one-fourth miles. All these flights were made at about thirty-eight miles an hour, the flight of the 5th occupying 38 minutes and three seconds. Landings were caused by the exhausting of the supply of fuel in the flights of the 26th and 30th of September and 5th of October, and in those of October 3 and 4, by the heating of bearings in the transmission on which oil cups had never been fitted. But before the flight on the 5th October, oil cups had been fitted to all of the bearings and the small gasoline can had been replaced with one that carried enough fuel for an hour's flight. Unfortunately, we neglected to refill the reservoir just before starting, and as a result the flight was limited to thirty-eight minutes. We had intended to place the record above the hour, but the attention these flights were beginning

* (This was a distortion of the truth as the reporters lost interest, as noted above.)

* The field was swampy and everywhere covered with lumps like molehills of soft earth. Not exactly an ideal flying field!

to attract compelled us to suddenly discontinue our experiments in order to prevent the construction of the machine becoming public.

"The machine passed through all these flights without the slightest damage. In each of these flights we returned frequently to the starting point, passing high above the heads of the spectators.

"If you think the contents of this letter would be of interest to the members of the Aeronautical Society of Great Britain, you are at liberty to communicate as much of it to them as you please. Hoping that we may have the pleasure of seeing you on your next visit to America, I beg to remain very respectfully yours, Orville Wright."

Exactly a fortnight after Alexander had read his letter, F. S. Lahm, an American in Paris*, informed the Aero Club of France, at a special meeting, of the flights the Wrights had been making, and he reported afterwards, "We separated with the great majority strong in the belief of a 'bluff americain.'"

Three years later Wilbur Wright wrote from France to his brother who was still in America, "The excitement caused by the short flights I have made is almost beyond comprehension. The French have simply become wild."

The Wrights were often accused in later years of secrecy in their experiments, and Orville commented on the accusation, on the tenth anniversary year of the first flight.

"Although made on a ground open on every side and bordered on two sides by much travelled thoroughfares, with electric cars passing every hour, and seen by all the people living in the neighbourhood for miles round, and by several hundred others, yet these flights have been made by some newspapers the subject of a great 'mystery.'"

It was not until January 1906, indeed, that the magnitude of what the Wrights had been doing became really world-wide news, outside enthusiastic aeronautical circles. Immediately after the meeting of the Society on December 15 1905, at which he presided, Baden-Powell wrote and congratulated the Wrights on their oustanding achievements, to which Orville Wright replied:

"Your letter of December 18 has been received. We thank you for the kind expressions of felicitation.

"Our first motor flyer, that of 1903, was in many respects like our later gliders, but of quite different construction in details as is required in a motor machine in order to withstand the shocks of landing. The landings of the glider were rarely at speeds of more than ten or fifteen miles, while those of the motor machine are often forty to fifty miles. We have also changed somewhat the construction and shape of the surfaces in order to secure a higher efficiency. We had not experimented long with the power flyer when we began meeting with difficulties that we had never encountered in gliding flight, so that we soon saw that our means of control were not sufficient. The machine has been passing through one change after another, and it was not until the latter part of September that we had all the dangerous features overcome. From there on progress was rapid, and it is now only a matter of perfecting the mechanical details to produce a flyer that will travel hundreds of miles in a single flight.

"In looking over our records of our experiments of the last three years, we find we have made 160 attempts to put the machine into flight. A number of these were failures in getting sufficient initial speed to support the machine when it left the track. But we find that we have averaged just one mile for every attempt, nevertheless. Our last flight of 1905 covered a distance equal to that of all the flights of 1904 combined, which were 105 in number.

"We are sorry that we are not able to give a more detailed description of our machine, but business considerations forbid. We have already closed a contract for governmental use in one country and have inquiries from several other countries."

Later in the year, in October, Orville Wright again wrote to Baden-Powell, who was keeping in close touch with the brothers and Chanute.

"We do not contemplate making any further experiments," wrote Orville, "as we do not think it necessary. Our time in the last year has been occupied in experiments with our motor, which we have greatly improved. Through our lack of experience in building gasoline engines, our first motors did not develop more than half of what they should have developed. But our work of the past year has been devoted more especially to the development of a reliable motor, one that can be depended upon to run continuously for long flights. Our new motors will enable us to carry two men and supplies of fuel for flights of several hundred miles. We have noticed considerable discussion of aviation in the English automobile papers, and that a number of persons are busily engaged in experiments. . . ."

Patrick Alexander paid a visit to the Wrights and in a lecture afterwards said:

"On my last visit I had been asked by the Brothers Wright not to divulge anything in connection with their machine. There are a few things, however, which I feel at liberty to say. Since the year 1900 the Wrights had flown over 160 miles. The brothers started with absolutely no knowledge whatever except that gained from books. Thereafter, in 1902, when I made their acquaintance, they had only the assistance of Chanute. In 1903 they first fixed screws to their machine. I would be the last to say, and here I should add the Wrights entirely agreed, that their machine was the final form of flying machine; but it was effective; the brothers had done everything they claimed to have done . . . they had no secrets except the confidence engendered by experience in aerial navigation."

The brothers designed their own propellers and wrote to Sidney Hollands, in January 1907:

* The father of Colonel F. P. Lahm who, in 1933, read the 21st Wilbur Wright Memorial Lecture on "Training the Airplane Pilot."

SMITHSONIAN INSTITUTION
Washington U.S.A.

June 13, 1904.

Dear Major Baden-Powell:

Your letter of May 25th has only just reached me, and I thank you for your kindly interest.

I have had a great deal of ill fortune in the experiments, which are temporarily suspended. To explain why would take some time, but I send an account of an "interview" by me, recently solicited by a newspaper here, which is authentic, and which will give you some notion of the way the matter stands.

I have not received the paper you speak of, describing the "Chute", but I have seen some account of it in the Scientific American, quoted probably from some English scientific journal. It seems to me to be a promising arrangement.

With much regard, I am,

Sincerely yours,

S. P. Langley

Major B. Baden-Powell,
32 Princes Gate, S. W.,
London, England.

FIGURE 29. Langley's letter of June 13 1904 to Major Baden-Powell (slightly reduced).

"The propellers we have been using give us such good results, that it is not probable that it would pay us to look for anything better. What we most need now is a perfectly reliable motor that is able to run continuously for hours at a time. We think that our new motors will give much better results than the one used in our last flights.

"Our new engine weighs 160 lb., not including water, tanks, or any of the other necessary equipments. Complete with water, etc., it will weigh about 250 lb. It will produce 25 to 30 h.p. This is only about two-thirds the weight per horsepower of our old motors. If we find that we can make it more reliable by building it heavier, we shall not hesitate to do so; for reliability is of a great deal more importance than lightness."

How right that last sentence is!

Well may it be asked what was happening in Great Britain at that time.

In the years 1905 and 1906 the JOURNAL of the Society was reporting the experiments of Patrick Alexander and W. G. Walker on a "vertical screw aerial machine." They had come to the conclusion, from experiments on propellers 30 feet in diameter, that 50 h.p. was required to lift a man's weight vertically. Alan H. Burgoyne was experimenting with an aluminium kite and reported that one had reached a height of between 10,000 and 12,000 feet. The July 1905 JOURNAL recorded that Sapper Moreton remained for over an hour at a height of 2,600 feet suspended from one of Cody's kites.

W. H. Dines described some of his experiments with kites for meteorological uses. He spoke with authority on meteorological matters.

But of descriptions of aeroplanes as such, experimental or otherwise, and experiments with them by people in Great Britain, there was little in the JOURNAL. In the October 1906 JOURNAL there was a description of Santos Dumont's box kite aeroplane which made the first European flight, and further details were given in the following issue of the JOURNAL. The October 1907 JOURNAL contained the first reference to the secret experiments of Dunne in the Highlands with his automatically stable machine. José Weiss gave a paper on "The Theory of Sailing Flight" in which he gave a description of his interesting model experiments carried

out on the Sussex Downs near Amberley. Chiefly, during those two years, progress in kites seemed to occupy would-be aviators.

Yet it might be of interest to note here that as early as April 27 1904, General Dunne wrote to Baden-Powell enclosing a memorandum from his son, Lt. J. W. Dunne, which began, "Though well aware of the magnitude of such a claim, I am confident that I have threshed out and finally solved the problem of stability in gliding aeroplanes."

How well those claims were substantiated in years to come is now well known. Dunne's memorandum in his own handwriting and numerous letters on the subject to Baden-Powell are in the possession of the Society.

In a lecture to the Society on April 27 1906, Sir Hiram Maxim discussed the experiments of the Wright Brothers and said, among other things, "It is impossible to over-estimate the changes that will take place during the next ten years in everything relating to civilized warfare."

By the end of 1905 the brothers were satisfied they had succeeded in demonstrating the practical worth of their machine. That year the machine was offered to the United States Government, and received what Wilbur Wright termed "a flat turn down." In the next five years the brothers found themselves in a maze of business negotiations with various individuals, syndicates and governments*, for which neither had much taste and very little experience. Much of the negotiations, together with the work in connection with the patent actions which were being fought, fell upon the shoulders of Wilbur. Wilbur showed himself as acute in business negotiations as he had shown himself to be in technical investigations. The constant strain ultimately took its toll and he was not left with sufficient reserves to struggle successfully against his last illness.

A paper by Octave Chanute, on "Recent Aeronautical Progress in the United States," was read at a meeting of the Society on May 27 1908 and published in THE AERONAUTICAL JOURNAL in July of that year.

> "The public attitude in the United States in 1906 and 1907 concerning aerial navigation has been one of expectancy and apathy," said Chanute. "The announcements of the marvellous success achieved by the Wright Brothers, which every investigation seemed to confirm, must have deterred many searchers from experimenting at all, until they knew how much remained to be accomplished in aviation. . . .
>
> "Meanwhile Aero Clubs have sprung up like mushrooms all over the country. The leading one is still the Aero Club of America in New York, which was organised in 1905. . . . Dr. Alexander Graham Bell has been experimenting with his tetrahedral kite. He tested on December 6 1907 his gigantic manlifting kite Cygnet consisting of 3,393 wing cells, presenting 1,966 sq. ft. of oblique surfaces and weighing with floats and passenger an aggregate of 600 lb. This was towed into the middle of a lake and raised against a wind of 21 m.p.h. by a tug boat. It exhibited that perfect stability which all previous experiments indicated and upon the wind's dying away it descended gently from a height of 168 feet but was broken on striking the water. It is to be tested again during the summer of 1908 with a view to eventually applying a motor."

Chanute referred then to the "Red Wing," chiefly designed by Lt. T. Selfridge, which made its trial trip on sleigh runners on the ice on March 9 1908.

> "It is a double-decked apparatus 43 feet across, the surfaces being arched both fore and aft and from tip to tip; the upper aeroplane being bowed downward somewhat in the attitude of the gull and the lower aeroplane being bowed somewhat to the attitude of the vulture when soaring. The total surface is 386 sq. ft. and the total wt. including aviator 570 lb. It is driven by a Curtiss motor of 40 h.p. actuating a screw propeller. At the very first attempt the apparatus left the ice after travelling only 200 feet and flew a distance of 319 feet from the point where it left the ice to the point of descending. It alighted somewhat clumsily and broke one strut, this being the first public exhibition of the flight of a heavier than air machine in America. . . ."

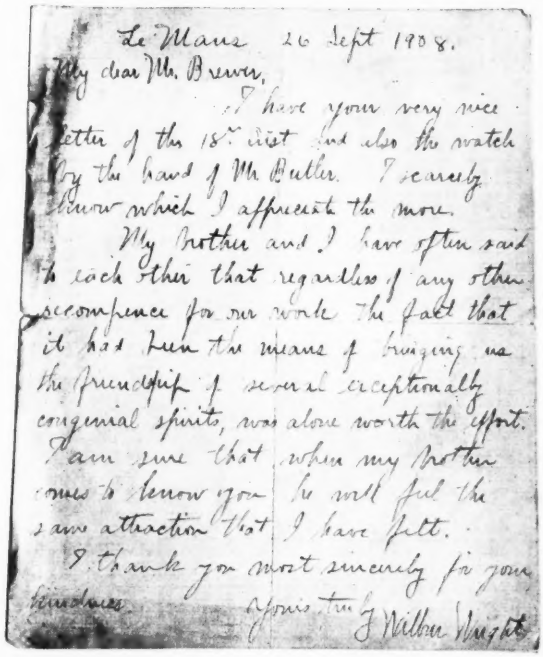
Not to be confused with the flights at Kitty Hawk evidently!

The general outlook in the United States in those years was pictured by Lt.-Col. G. O. Squier on the occasion of the reading of the first Wilbur Wright Memorial Lecture before the Society by Horace Darwin, F.R.S., in 1913. Col. Squier was seconding the vote of thanks to the lecturer. He had been with the Wrights for two years working out experiments when the American Government were taking over their first aeroplane.

> "The achievements of Wilbur Wright," he said, "and his brother are a credit to the Anglo-Saxon people, and therefore I think it is very proper that England and America should join in common recognition of his most valuable work. I first became acquainted with the Wrights through my association with the American War Department, and got to know them as well as people usually do know each other. They were not easy to get acquainted with.
>
> "I would like to refer to a document prepared at that time, which has now some historic interest. It is hardly believable, but five years ago the first specification for aeroplanes ever contracted for was

* Orville Wright wrote, on behalf of the Wright Cycle Company, on November 25 1905, to the British Military Attaché at Washington, "At the request of Lt.-Col. Capper we gave the British Government the first chance to secure the use of our invention in foreign countries, and did not take the matter elsewhere until a number of months had passed. But the progress of the later negotiations has been such as to make it possible that a crisis will be reached before the British War Office has all obtainable information before it and is ready to reach a decision as to whether it will take up the flying machine at this time."

The British Military Attaché wrote that all he was to do was to go to Dayton and see the machine fly and report on what he saw. As the Wrights had ample proofs in witnesses and photographs of their claims, they refused to make a special flight to satisfy, as Wilbur Wright wrote, "what may be only curiosity."



Le Mans 26 Sept 1908.

My dear Mr. Brewer,

I have your very nice letter of the 18th inst and also the watch by the hand of Mr Butler. I scarcely know which I appreciate the more.

My brother and I have often said to each other that regardless of any other consequence for our work the fact that it had been the means of bringing us the friendship of several exceptionally congenial spirits, was alone worth the effort. I am sure that when my brother comes to know you he will feel the same attraction that I have felt.

I thank you most sincerely for your kindness.

Yours truly
Wilbur Wright

FIGURE 30. Original of a letter from Wilbur Wright to Griffith Brewer. Written on a sheet of squared paper from Wilbur's note book. (Slightly reduced in size.)

drawn up in the American War Department in one afternoon, and on a single sheet of paper. The specification was very simple, and it was issued publicly, as is required by law, on the 23rd of December 1907.

"In order to understand the situation you must remember that the Government had granted £10,000 to Professor Langley* for experimental work. At the time his accomplishments were not generally appreciated, and the support accorded him was regarded by many as a waste of public money. Consequently the public was in no mood at that time to listen favourably to any proposal to spend still more public money on aircraft.

"But the Wright Brothers came to the War Department and informed us of what they could do, and they so convinced the authorities that money was found to give them this first contract. The contract promised to pay £5,000 for any heavier-than-air machine capable of carrying two people weighing in the aggregate 350 lb. with petrol sufficient for 125 miles at a speed of 36 miles an hour. The issue of the contract was criticised severely, and the War Department was supposed to have lost its head. . . .

"In due course the American machine was delivered to the Government. People heard many rumours about it, but never having seen anyone fly they did not believe in it. On September 19 1908 Orville Wright went out early in the morning and flew for 58 minutes; only a few soldiers observed him. The effect was marvellous; it disorganised Washington completely. That afternoon he flew again at half-past four, in the presence of every man, woman and child who could get up to the aerodrome. . . .

"During the period of the completion of the contract it was interesting to study the character of Wilbur Wright and his brother. They kept their one idea always in sight. Nothing would swerve them from their work. They were there to fulfil this contract.

"No one could ever tell when they would fly. Frequently it happened that the President would drive over to see them fly, and almost as often he would have to drive back again disappointed. They were absolutely uninfluenced by any outside forces. Even when Congress came over *en masse* and they had the entire Government looking at them they would not fly if they thought it inadvisable. Not only would they not fly, but they would not say why either.

"I have never known men with a more wonderful knowledge of the physical properties of materials. They knew the different kinds of wood and metals and how to prepare them. Their attention to absolute detail was profound, yet never without a reason."

It was in 1906 that Griffith Brewer first heard about the Wrights' flying achievements, apart from newspaper reports, which he did not credit. He was preparing to take part in the first Gordon Bennett balloon race from Paris, when "Patrick Alexander came up to my balloon car and told me the Wrights had actually flown in America," to quote Brewer's own acount of the way the news came to him, when he was speaking in April 1938 at Greenfield village in the United States, at the dedication of the Wrights' home and original workshop which had been bodily transported there. "But I could not believe his news, and he smiled in friendly tolerance at my unbelief. Although I had known Patrick Alexander for fifteen years and would believe him in everything, I felt there must be a catch somewhere and that mechanical flight, which I had always regarded as impossible, had not really been accomplished."

Brewer was always hard to convince, despite the direct evidence of Octave Chanute, Baden-Powell, Charles Rolls and other members of the Society.

In March 1907 Rolls, who had recently returned from America, wrote to *Ballooning and Aeronautics*:

"While in America I spent some little time with the Brothers Wright. I also took the opportunity of making a number of inquiries as to independent persons who had actually seen the various flights of the Wright machine. The result is that I am quite convinced and perfectly satisfied that they have attained in flight even more than has been published in the newspapers.

". . . These remarkable men are extremely modest, and it is very difficult to get them to talk at all about their achievements or to claim anything, but when pressed on the point, they admitted that their new machine was certainly capable of covering the distance involved in the *Daily Mail* prize; although an interesting point, they added, was that the personal

* *See* page 746.

FIGURE 31 (*left*). Griffith Brewer's first flight, with Wilbur Wright, Le Mans, 1908.

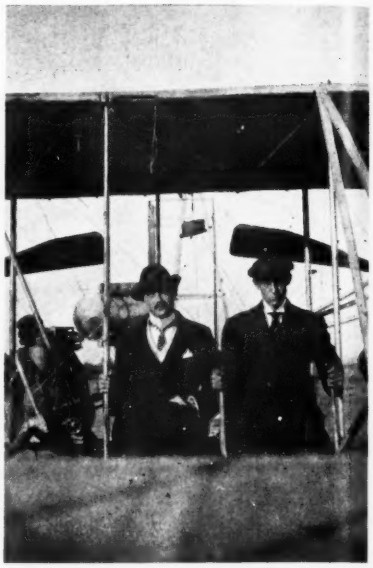


FIGURE 32 (*right*). The Hon. C. S. Rolls and Wilbur Wright, Le Mans, 1908.

element was an important one to be considered, for they had found that the strain upon the human system of a single individual, involved by the navigation of the aeroplane, was excessively great. The control of the equilibrium, the vertical steering, the horizontal steering, the control of the carburation, ignition and speed of the engine, were matters which kept the mind and the body under a severe continuous stress. At first they found that a flight of one mile resulted in extreme fatigue but after practice a much greater distance could be covered with the same fatigue."*

"Then in 1908," continued Brewer in his 1938 speech, "came the news that Wilbur Wright was actually flying in France. Members of the Aeronautical Society of Great Britain went over to Le Mans in doubt and returned convinced that the age of flying had arrived.

"My old associate in balloon races, Charles Rolls, founder of the Rolls-Royce motor car firm, when he heard that I was going to Paris by the night train invited me to dine with him and inquired in a whisper: 'Brewer, why are you going to Paris?' to which I replied: 'Don't tell anyone, but I'm going to see Wilbur Wright fly.' He laughed and said: 'Well, don't tell anyone, but I have just returned from seeing him fly.'"

Rolls, in fact, had wanted to be the first Englishman to fly with the Wrights or to fly one of the Wright aeroplanes in England, and following his visit Wilbur had written to his brother in America to ask how soon one machine could be sent across, and the cost.

"That is how flying came to us in Europe," continued Brewer. "From that moment we kept our balloons for pleasure races and accepted the arrival of mechanical flight. . . . I arrived at Le Mans after a heavy night journey and walked down beside the field to the shed on the right hand side of the road. There, opposite the shed, out in the middle of the field, was the first machine, or rather the machine of 1908, with Wilbur Wright tuning it up.

"There was quite a crowd buzzing around Wilbur at his work, and, as you know, a crowd of that kind is very disconcerting, so I had some compunction in adding to the crowd, and instead of going out to the crowd alongside the machine I sat down by the shed and smoked my pipe.

"A mechanic came from the machine over to the shed to fetch a spanner, so I gave him my card to give to Wilbur Wright, and when he returned I saw Wilbur Wright look at that and he nodded across to me and then went on with his work.

"Time went on and there was no flight. Ultimately the machine was wheeled back to the shed. The crowd dispersed: they all went back to Le Mans, and I began to think I was forgotten. Sitting with my back to the shed (the machine had gone inside and Wilbur Wright had gone inside) I wondered whether I should sit out there indefinitely. Then out came Wilbur Wright and said: 'Now, Mr. Brewer, let's go and have some dinner.' We went across to Madame Pollet's inn and had a very nice simple dinner. We talked of all things American and I did not bother him with aviation. That was probably his first rest from the subject of flying since he left his home in Ohio many weeks before.

"We continued our talk on topics of mutual interest long into the evening, both being keenly

* It is interesting to note that Dr. F. W. Lanchester, in his paper on "The Wright and Voisin Types of Flying Machine," read before the Society on December 8, 1908, said, "In the case of the Wright machine it is claimed by Mr. Wright himself that the stability depends entirely on the skill and address of the aeronaut. . . . The author's own observations on the flight of the Wright machine fully confirm the statement that *Mr. Wright does depend entirely on his manipulative skill.*"

nterested in American life and habits, and when we strolled back to the shed where Wilbur turned in for the night I said good-bye and felt I had known him for a long time."

That was the beginning of a close friendship which lasted throughout the lives of the two brothers and Griffith Brewer. The latter, indeed, devoted much of his life and energy to ensuring that the achievement of the brothers should take an inviolate place in the history of aviation.

There is, in the possession of the Society, an autograph letter from Wilbur Wright to Griffith Brewer which is revealing. It is reproduced in facsimile on page 775, written on a page of squared paper torn out of a notebook Wilbur was using.

That year 1908 was a year of unbelievable excitement, enthusiasm and interest in flying, a year which only comes when the world is suddenly confronted with something entirely new in its experience.

"The excitement caused by the short flights I have made," wrote Wilbur to his brother who was in America flying, "is almost beyond comprehension. The French have simply become wild."

Nor were the members of the Aeronautical Society less excited, though they expressed their feelings in a different way and in a different language. Griffith Brewer, Charles Rolls, Baden-Powell, Eustace Short, Hiram Maxim, Col. Fullerton, Patrick Alexander, Alec Ogilvie, T. P. Searight, Francis McClean, Moore-Brabazon, F. W. Lanchester, E. S. Bruce, to name but a few, went to France to see the most astonishing sight in the history of the world up to that time, a sight now too mundane to make most people look heavenwards.

And all went to France with a secret ambition to fly or be flown.

Wilbur Wright took up his first Englishman in the person of Griffith Brewer.

"I then enjoyed the greatest thrill it had ever been my lot to experience," said Brewer afterwards. "The weight was hoisted up on the pylon, the propellers were started, being driven from the engine by the chains, and then the machine was released and we were catapulted along the rail. The machine became airborne and we raced down the field level with the tree tops. We turned on a perfect bank and came back down the field and finally landed near the spot from which we had started. . . . During that first flight I remembered wondering whether we should really rise from the rail, and then a feeling of elation when the grass slipped away backwards and downwards and the machine seemed to be sitting on nothing. There was no sense of travelling except by the appearance of the earth moving backwards, and on looking upwards without the sense of movement inherent in all other vehicles which are supported on wheels or on water. . . . Rolls made his first flight immediately afterwards, then Butler and later Major Baden-Powell."

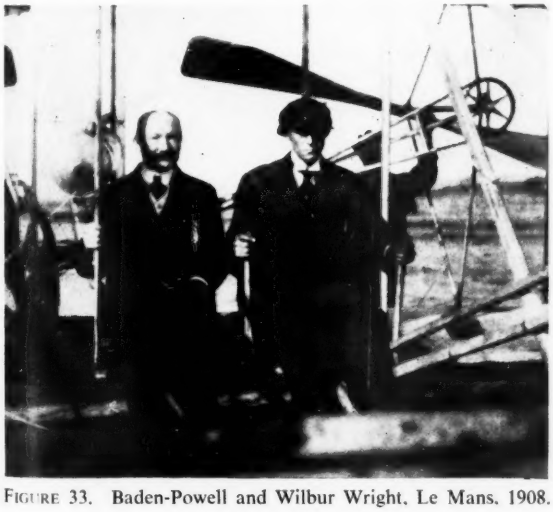


FIGURE 33. Baden-Powell and Wilbur Wright, Le Mans, 1908.

FIGURE 34. Major B. F. S. Baden-Powell, the Hon. C. S. Rolls, Wilbur Wright, and F. H. Butler at Le Mans, outside Madame Pollet's estaminet, 1908.

Of his first flight Rolls wrote:

"The roar of the engine commenced, the starting weights were released, and off we went with a bound, but not a worse one than when starting on a switchback. Before reaching the end of the rail we had left it and were in the air. We were now flying.

"Once clear of the ground the feeling of security was perfect and I was able to watch with great interest the movements of the operating levers. . . . Sometimes we flew above the trees, sometimes we flew 3 feet off the ground, entirely at the will of the operator. . . . The side gusts and varying currents we encountered at times caused gentle dipping motions not unlike a switchback, but always under complete control."

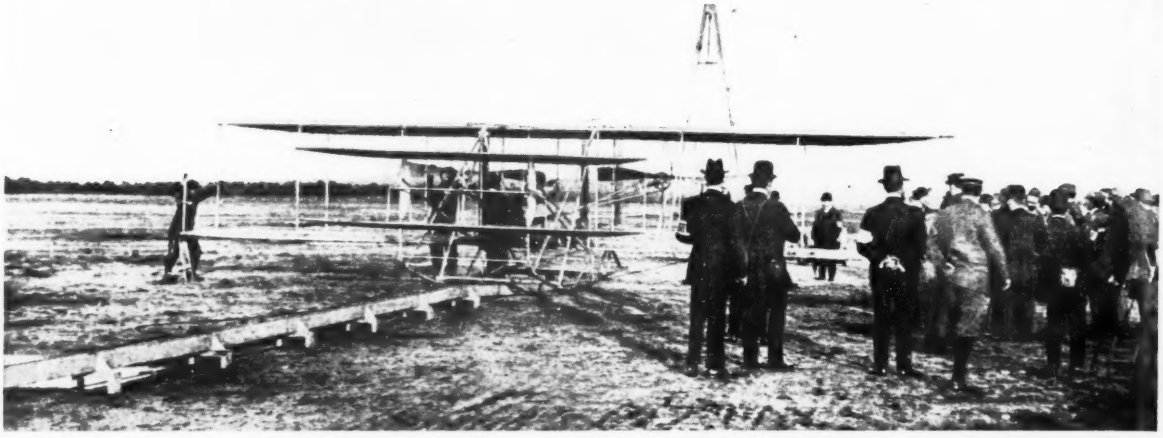


FIGURE 35. Wright machine at Camp d'Auvours, Le Mans, 10th October 1908, showing the launching track with the derrick in the background.

Baden-Powell, who stayed at Le Mans for a week, made long and careful notes of the machine and the flying.

"I twice made an ascent with Mr. Wright," he wrote in a memorandum to the Hon. Secretary of the Society at that time, "but the first attempt only lasted a few seconds, the start being made in a light cross wind. It however gave one some experience of starting and landing. The second flight lasted 4 min. 25 secs."

Baden-Powell reported that Wilbur Wright had said the engine of the machine at Le Mans had been designed to give 30 h.p., and it gave that power on its first few tests, but in France he was never able to get more than 22 h.p.

In the paper read to the Society on December 8 1908 by Dr. F. W. Lanchester on "The Wright and Voisin Types of Flying Machines," he made a comparison of the two types. Lanchester had been over to France to watch Wilbur Wright fly and to ask all the questions, though he didn't get all the answers!

"The Wright machine," said Lanchester, "is astonishing in its simplicity—not to say in its apparent crudity of detail—it is almost a matter of surprise that it holds together. The Voisin machine has at least some pretensions to be an engineering job.

"Mr. Wright defends his methods by asking what would be said by an engineer to the rigging of a sailing vessel if shown it for the first time, and, to some extent, the analogy is a good reply to the objection. Still the author feels (perhaps wrongly) that there is a considerable amount of the Wright 'mechanical detail' that might be revised with advantage; at least, before the machine is placed in the hands of the private user. However, 'the proof of the pudding is in the eating,' and in spite of the rudimentary character and aggressive simplicity of the constructional detail of the Wright machine it appears not to come to pieces, but continues to fly day after day without showing any signs of weakness or disintegration."

Lord Northcliffe, in seconding a vote of thanks to

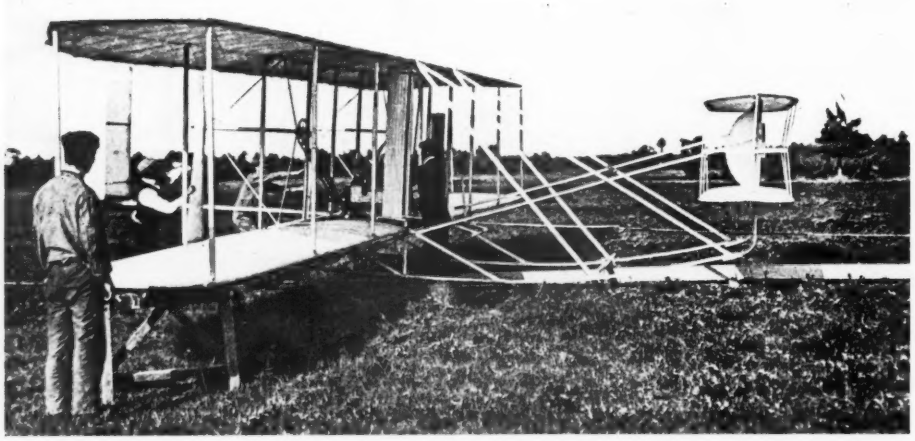


FIGURE 36. The Wright machine being put on the launching track.

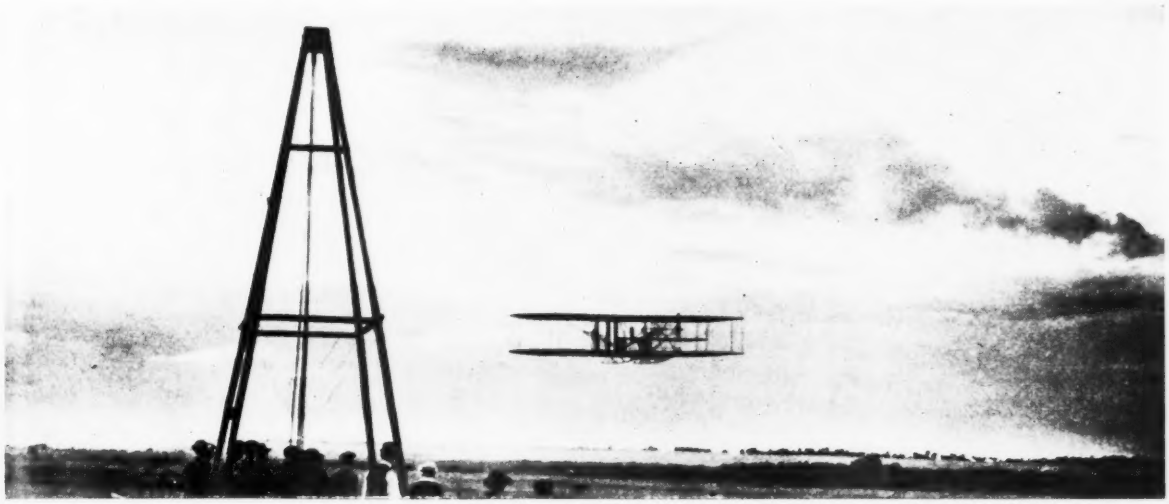


FIGURE 37. Wilbur Wright, flying for one hour 31 minutes, in the late evening of September 21 1908, at Camp d'Auvours.

Griffith Brewer after the latter had read the Fourth Wilbur Wright Memorial Lecture in 1916, said:

> "I remember that first aeroplane. It was very rough and very simple. The motor was not only one of very small power, but from the point of view of modern flying machines, very crude. The Wright Brothers, however, were not people who took very much interest in appearances, and . . . the fact remains that after more than a hundred years of experiment with aeroplanes, these two brothers were the first people in the world who made a machine to fly, and flew it."

At a Council meeting of the Society, held on November 9 1908, with E. P. Frost, the President, in the Chair, and present Major B. F. S. Baden-Powell, a past President, Sir Hiram Maxim, Dr. Napier Shaw, Col. J. D. Fullerton, the Hon. Secretary, and Mr. Becher, the Hon. Solicitor:

"The Council approved of the presentation of the Gold Medal to the Wright Brothers, 'In recognition of their distinguished services to aeronautical science.'"

This beautiful medal was designed by a member of the famous Wyon family, which was also responsible for the design of the early classic head of the young Queen Victoria which appeared on the coinage and the first postage stamps of the world, a head which has never been surpassed in the beauty of its line. A later member of the family designed for the Society the British Gold Medal for Aeronautics, showing the head of Sir George Cayley and his first model aeroplane of 1804; the British Silver Medal for Aeronautics showing the Henson monoplane of 1842 and the Stringfellow model monoplane of 1848; and the President's Badge of Office from which the present badge used by the Society is taken.

The second meeting of the 44th Lecture Session of the Aeronautical Society of Great Britain was held in the Lecture Hall of the Institution of Civil Engineers on May 3 1909. It was at this meeting, far more crowded than any previous meeting ever held by the Society, that Wilbur and Orville Wright were presented with the Gold Medal of the Society.

The proceedings on that occasion are reported in the JOURNAL of the Society for July 1909, and need not be

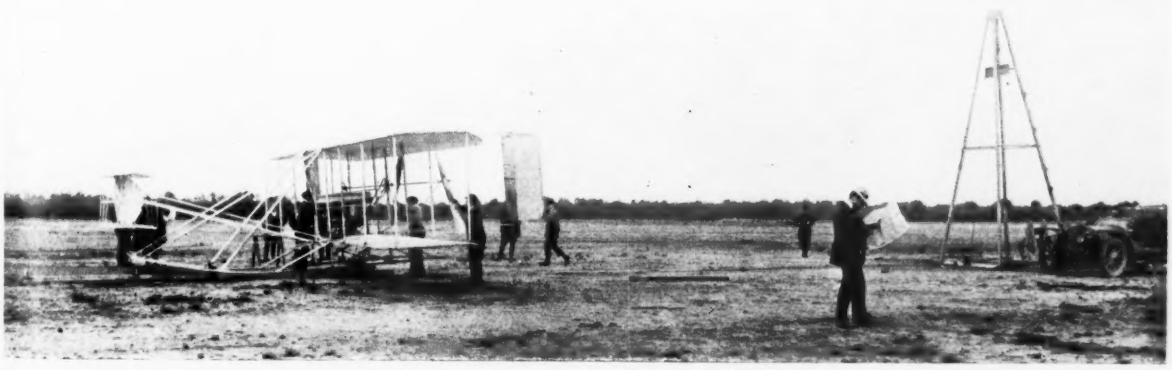


FIGURE 38. Wright machine at Pau showing the starting pylon.

repeated here *in extenso*. Wilbur Wright replied to the laudatory speeches of the President, E. P. Frost, Major Baden-Powell, E. S. Bruce and Colonel Capper, chief of the Balloon Department at Aldershot. The latter reminded the audience that he had visited the two brothers in America in their early experimental years.

> "I think anyone who has had the privilege of knowing them," he said, "would agree with me in saying that they had something to be even more proud of than their great invention, and that was their simple-minded honesty, kindness, and the way they stuck to their friends. As to the value of their invention in the future, words fail me to say what would be the effect of flight on our country and on all nations of the world from the points of view of war and of peace."

Wilbur Wright began by saying: "It is with a feeling of peculiar pleasure that my brother and I find ourselves to be the guests of your Society tonight, a Society which we have known by reputation—and to a great extent by the names of the individual members—ever since we have been studying the problem of flying. . . ."

At the beginning of this paper is printed the tribute Wilbur Wright then paid to the Society in his next few words. He continued:

FIGURE 39. Orville Wright and Lord Northcliffe at Pau, 1909.

> "After nearly fifty years at last we find man flying. For this reason, and during all these years, until very recently in fact, until after man had begun to fly, the Aeronautical Society of Great Britain was the only Society in the world, as far as I know, devoted to the subject of flight as distinguished from ballooning."

The brothers and their sister Katharine were only in England on that occasion for three whole days, but

FIGURE 40. A group hauling on the rope of the Wright machine at Pau, 1909, including Lord Northcliffe, Arthur Balfour, Wilbur Wright, and on the right, Arthur Mee.

FIGURE 41. The first presentation of the Gold Medal of the Aeronautical Society—on May 3 1909, to the Wright Brothers. In the photograph may be seen (*left to right*) E. S. Bruce, Dr. Shaw, Lt.-Col. Templer, Col. Trollope, Wilbur Wright (*standing*), E. P Frost (President), Orville Wright, J. C. Inglis, Major Baden-Powell and Sir Hiram Maxim.

in that time they were entertained by the Society and the Aero Club and taken to visit Sheppey and the Short Brothers' factory, where the first Wright machines were being built.

At the luncheon given by the Aero Club to the Wrights it is of some interest to note that one of those present was James William Butler, who was one of the members of Council of the Aeronautical Society of Great Britain in the year of its foundation, 1866. Truly for him the wheel had turned full circle, for he had seen that first model of Stringfellow fly, and the first aeronautical exhibition in the world, held by the Society at the Crystal Palace. Among others present were Francis McClean and J. T. C. Moore-Brabazon, both happily still alive.

In 1910 Griffith Brewer paid a visit to the brothers at Dayton and the following year Wilbur Wright visited Europe.

FIGURE 42. The Gold Medal of the Society, first presented on May 3 1909—to the Wright Brothers.

On May 10 1911 he wrote to Brewer from Berlin:

"Matters have become so interesting in Berlin that I have been unable to get away. I even find that it will be necessary to be here a week or so hence.

"So I have concluded to go to Paris on Monday and after a visit to England to come back again to Berlin to see whether the criminal laws of Germany are such as to put the most powerful business man in Germany into jail for an attempt to commit what would be a criminal offence even in the attempt in America and I think in England also. So you see that matters are really very interesting here and that I am depriving myself of the pleasure of your company in England not without good reason.

"I enclose a copy of a letter written by Esnault-Pelterie to his French business associate. Such a letter is most laughable when one thinks of the quite different tone in which they spoke of our patent suit in France when I first reached France in March. It reminds me of a cartoon I saw in a German paper some weeks ago when the French papers were protesting against including Berlin in the aeroplane race Paris-Brussels-Berlin-London-Paris. The first picture showed French soldiers of 1870 marching off to the war to the cry of 'à Berlin.' The second showed the French of 1911 grabbing the flying machines by the tails and shouting 'pas à Berlin.'

"In February the French were so bold that they were crying 'On to Berlin' to attack the Wright German patents. Now they are even more earnestly crying 'Keep away from Berlin.' The French are really very amusing sometimes.

"Please do not kill the fatted calf in anticipation of my arrival in England. It might spoil before I get there. But laying aside all joke, I really am unable to fix definitely my arrival and if the telegraphic notice which I shall send in any event finds you gone to Switzerland or Scotland, I will run down and spend a few weeks with Mr. Ogilvie while you are getting back. I have cried 'Wolf' so often that I fully expect to find you gone about other business when I really do come.

"With best regards to Mrs. Brewer and yourself.

"Yours truly, Wilbur Wright."

On July 9 1911 Wilbur wrote again from Berlin:

"Today I took a stroll down to Tempelhofer field where Orville did his flying in Berlin. I was rather surprised to find three or four games of cricket going on in different parts of the field.

"You will wonder what cricket looks like and sounds like in Dutch, but as I have never really seen a game in England I do not know how to compare it with the genuine article. While you are in America have Orville take you to see a ball game. The conduct of the crowd will interest you immensely whether the game does or not. A baseball game at a school for deaf mutes would be noisy compared with this German crowd at a cricket game.

"Tell Bettie that I saw a whole lot of lions and tigers and bears and elephants, and nice little ponies and some monkeys, but I couldn't find any fairies. I think may be they do not grow in Berlin. If I find one I will catch it and ask it to go over to England with me the next time I go there."

That reference in Wilbur Wright's letter to lions and tigers and fairies was really something quite characteristic of the man. "Children found him an authority on the subject of fairies," wrote Brewer when making an appeal for the Wilbur Wright Memorial Fund in July 1912, "for who could know more about such charms than the man who had acquired their principal accomplishment. Several children will remember to the end of their lives how he hunted for fairies in the box borders in the garden, and how, although never really successful, he nearly caught them several times."

Another member of the Aeronautical Society was Alec Ogilvie who had been making and experimenting with kites for a good many years. He joined the Society

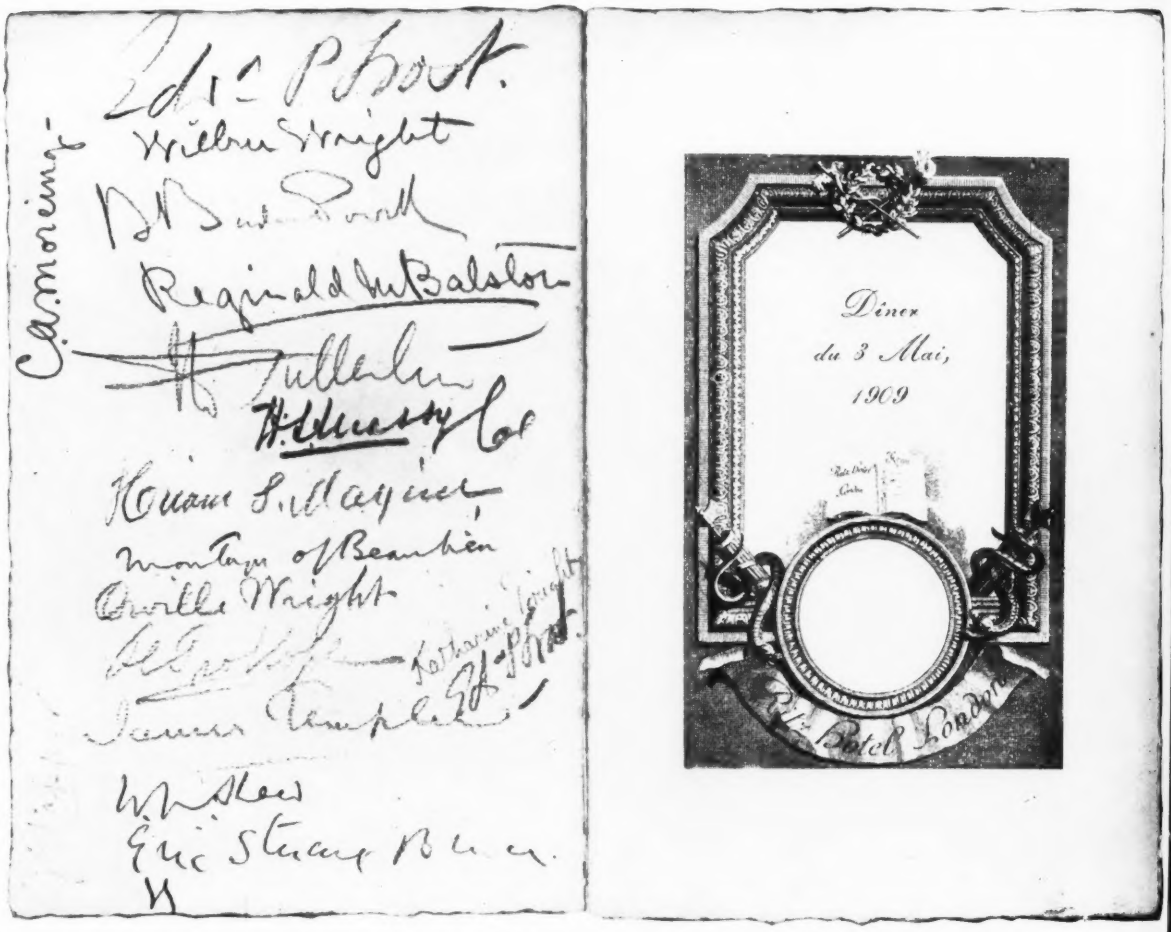


FIGURE 43. Menu of the Council Dinner given to the Wright Brothers and Katharine Wright, May 3 1909, and signed by all three and by members of Council of the Aeronautical Society.

FIGURE 44. Guests at the luncheon given to Wilbur and Orville Wright, and Miss Katharine Wright, at the Carlton Hotel, May 3 1909, by Mr. Frank Hedges Butler, one of the founders of the Royal Aero Club. From left to right: Mrs. Iltid Nicholl (née Miss Vera Butler), the Hon. C. S. Rolls, Mr. James William Butler, Mr. Orville Wright, Miss Katharine Wright, Mr. Frank Hedges Butler, Mr. Wilbur Wright, General Sir Charles Hadden, K.C.B., R.A. (representing the Army on the Aerial Navigation Commission), Captain Hugh Iltid Nicholl, Major Baden-Powell, Mr. J. T. C. Moore-Brabazon, General John Spencer Ewart, C.B. (Military Secretary, War Office), Mrs. Griffith Brewer, Professor A. K. Huntingdon, Mr. Harold Perrin (Secretary of the Aero Club), Mr. Griffith Brewer, General G. F. Ellison, C.B. (Director of Organisation, War Office), Mr. Roger W. Wallace, K.C., Colonel Sir Edward W. Ward, K.C.V.O., K.C.B. (Permanent Under-Secretary of State, War Office), and Mr. Francis McClean.

FIGURE 45. The Wright Brothers at Shellbeach in 1909.
Back row, from left to right: T. D. F. Andrews, Oswald Short, Horace Short, Eustace Short, Francis McClean, Griffith Brewer, Frank Butler, Dr. W. J. S. Lockyer, Warwick Wright.
Front row, from left to right: J. T. C. Moore-Brabazon, Wilbur Wright, Orville Wright, Hon. C. S. Rolls.

in 1901 and attended the 1902 address by Baden-Powell on the State of Aeronautics. Curiously enough his signature on the attendance sheet is next that of Griffith Brewer, though it was six or seven years before they got to know one another.

Griffith Brewer and Ogilvie, in their different ways, had closer contacts with the Wrights over longer periods than any other members of the Aeronautical Society. In the autumn of 1908 Ogilvie and T. P. Searight went into a partnership with a view to building an aeroplane and learning to fly it, by towing it behind a car on a large flat area which they had found at Camber Sands near Rye, Sussex.

In December they went to France to see what was going on. Ogilvie has described that visit in his Wilbur Wright lecture of 1922 to which nothing need be added except that his diary on December 16 1908, after describing Wilbur Wright's flights, noted his opinion of the machine as "Practical and travel stained," and that on the next day, when he first spoke to Wright he records: "Raining hard. Saw W.W. at Dauphin Hotel. Quiet modest fellow. Advised against towing behind car." The diary entry shows clearly that far from being at all "cagey" Wilbur Wright gave them a piece of very sound advice.

On a second visit on December 30 1908 Ogilvie was alone and had a long talk with Wilbur, when the latter expressed the opinion that Englishmen should make good flyers because they were good horsemen! That meeting was important as far as Ogilvie was concerned, for Wilbur told him that he had made arrangements for Short Bros. to make six Wright machines powered with engines from Messrs. Bollée of France. The first of these machines was bought by Rolls, and the second Ogilvie requested for Searight and himself.

The following day Wilbur made a flight of 2 hours 18 minutes, covering 130 kilometres, far outdistancing all competitors.

Early in March 1909 Ogilvie went to Pau where Wilbur Wright had gone for further flying and training of three French pilots under contract. Orville Wright, then recovering from his serious accident at Fort Myer, and his sister Katharine, had joined him there. During the three or four days Ogilvie was at Pau, Orville gave him invaluable advice about the handling of a machine at Camber and, as tuition to English pilots was unlikely, suggested that experience on a glider would be a means of self tuition. During this visit of Ogilvie, Wilbur told him that they had patented an automatic balancing apparatus, by means of which the machine would keep itself at a definite angle to the air and also balance itself sideways. Although the idea had been patented in 1904 the two brothers had been so busy with negotiating and demonstrating their flying claims, that they had had no time to experiment.

In May 1909, after the presentation of the Society's Gold Medal to the Wrights, Wilbur confirmed to Ogilvie the impossibility of giving tuition to English flyers and urged, as his brother had done, the advisability of learning to control a glider, so that he would have the feel of controlling a machine in the air.

The brothers had developed different methods of lateral control. Wilbur's system consisted of a universally jointed lever, which moved sideways to warp the wings and fore and aft to actuate the rudder. In Orville's system, the control lever only moved fore and aft but it had a small cranked handle at the top. When moved forward with the handle in line, the left wing was pushed down and the correct amount of rudder applied. To make a left turn the handle was cranked to the left

FIGURE 46. Orville and Wilbur Wright, Griffith Brewer, Professor Huntingdon, J. T. C. Moore-Brabazon and others at Shellbeach, May 4 1909.

according to the size of the turn and the whole lever operated for lateral balance (*see* Fig. 55).

Ogilvie and Searight had a glider made by T. W. K. Clarke who, as a member of Council of the Aeronautical Society, later suggested the Wilbur Wright Memorial lectures. The glider was on the general lines of the 1902 Kitty Hawk glider, with Wilbur Wright's system of control.

In August and September 1909 both men made a number of glides but could not get the proper hang of the control till Orville wrote and explained. After that progress was rapid.

In October 1909 Orville paid a visit of inspection to Short Bros. works at Shellbeach and praised the workmanship being put into the machines. At the end of the month the second of these machines was towed by road to Camber and on November 7 1909 Ogilvie made his first powered flight.

In August of the following year, after a long discussion with Griffith Brewer, Ogilvie went to Dayton to learn the Orville system of control and possibly to represent the Aero Club in the Gordon Bennett Race with one of the small racing machines which the Wrights were thinking about. Orville met him at Dayton station and took him to see Wilbur who was busy in the factory.

On September 10 Ogilvie's diary reads: "O.W. made flights of 10 and 28 minutes. Took me up 5 min. Nearly dark. Wonderful control and steady flight. No front rudder. Back rudder worked by wires."

The double front elevator which had been used was now replaced by a single tailplane, the angle and camber of which could be controlled.

FIGURE 47. Orville and Wilbur Wright visit Messrs. Short Brothers factory in May 1909. On the left Horace Short. In the background Oswald Short. On right, Griffith Brewer.

For a month Ogilvie was flying under instruction from Orville and others, learning to control the standard machine with the Orville system at Simms field*, Dayton and at the St. Louis flying meeting. During this time Ogilvie learnt what a remarkable family the

* Also called Huffman Prairie.

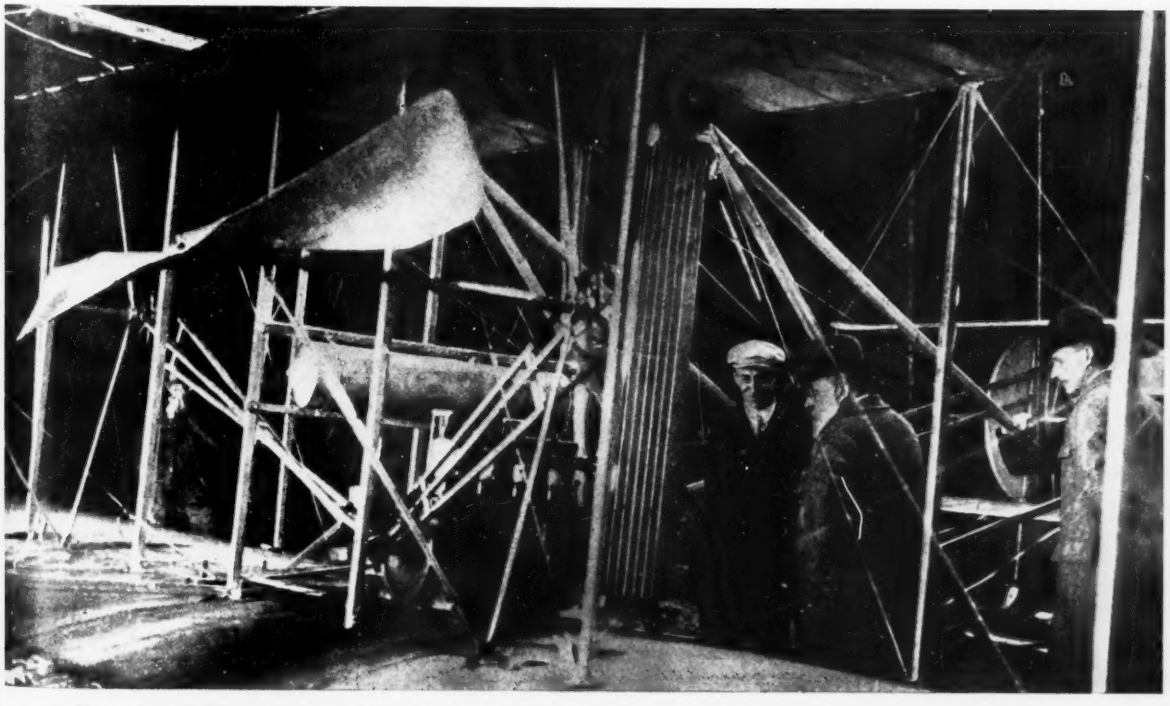


FIGURE 48. Wilbur Wright explaining to King Edward VII at Pau, in France in 1909, the construction of the aeroplane.

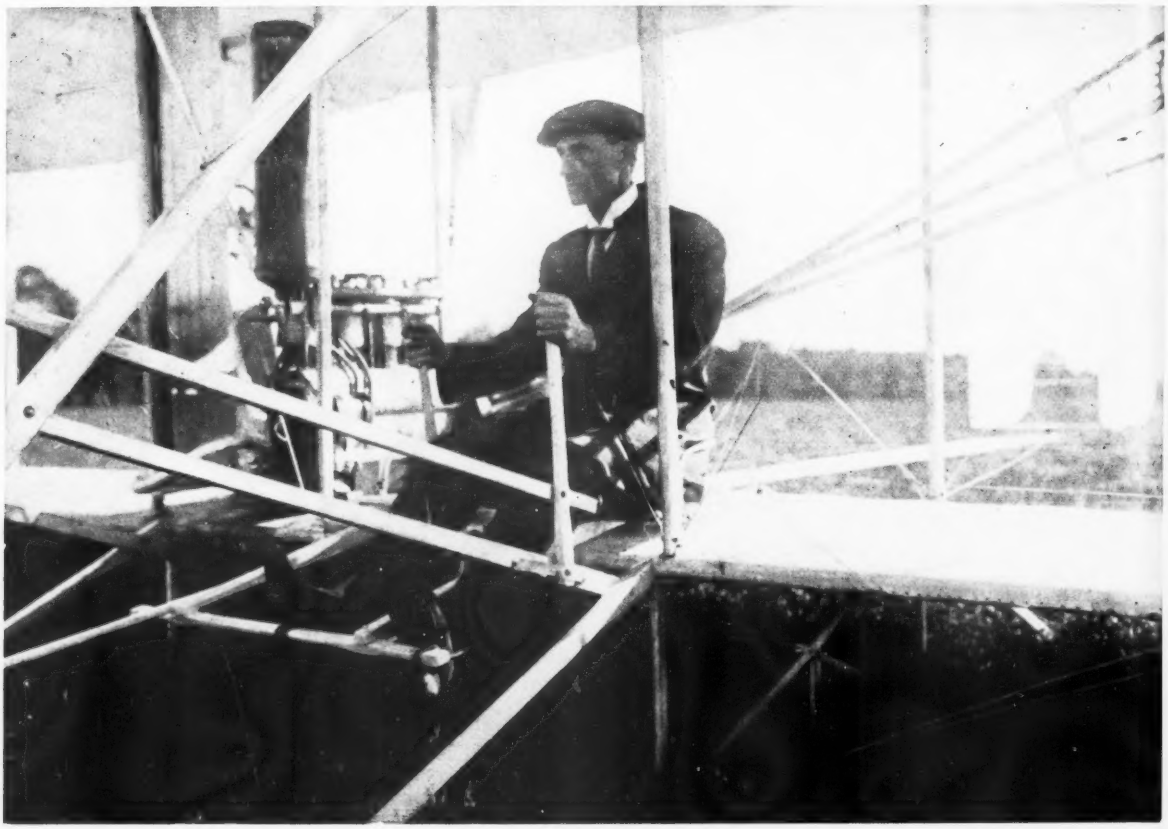


FIGURE 49. Wilbur Wright at the controls of the Wright machine.

Wright family was. He was treated with that great kindness and consideration so characteristic of America, and he had the advantage of being present in innumerable discussions and arguments, almost violent on occasion. Ogilvie remarked that whenever the Aeronautical Society came up in conversation, it was always referred to by the Wrights with great respect.

By October 13 1910 the Wright racer was ready for trial. This little machine with the standard 4-cylinder engine of 35 h.p. and wings of 26 ft. 8 in. span was flown by Orville with perfect confidence. Its speed was 56 m.p.h. and it could climb at 400 ft. per min. Later on it was found capable of climbing at nearly 600 ft. per min. During the following week Ogilvie put in as much practice as possible on the machine before going to New York with Katharine Wright and her two brothers.

For some time past the Wrights had decided to give no more personal exhibitions of flying and the small racing machine fitted with an 8-cylinder engine of 60 h.p. was to be flown in the Gordon Bennett Race by Brookins, one of their most brilliant pilots, as representing the American Aero Club.

However Orville, who was very fond of flying and seized on any excuse, took up this machine at Belmont Park to test it and made a circuit at 75 m.p.h. which was almost double the speed of that of their standard machine. In the race on the 29th of October Brookins crashed and the race was won by Grahame White on a 70 h.p. Bleriot, his fastest lap being at 63½ m.p.h. Moisant, an American, on a 50 h.p. Bleriot was 2nd with a best lap of 50 m.p.h. Ogilvie had a forced landing and was 3rd with a best lap of 55 m.p.h. The span of his machine in this race was 20 ft. 6 in.

During all this time in America a deep friendship had been growing up between the brothers and Ogilvie, a friendship which Ogilvie expressed so movingly in his Wilbur Wright Memorial Lecture, when speaking of Wilbur's death: "I felt I had lost an elder brother." Both, following the Gordon Bennett Race, had expressed their congratulations and pleasure that he had come through the race without accident.

Ogilvie returned to England in November and in December Orville paid him a visit at Camber Sands, and on the following day, with Griffith Brewer, the two went to Eastchurch to watch Dunne making a stalled flight on his biplane. An official report that Dunne had flown with hands off was signed by Orville Wright and Griffith Brewer at the time.

In 1911 the Gordon Bennett Race was held in England, as it had been won by an Englishman the previous year. Wilbur Wright had come over to Europe in March to visit France and Germany in connection with the Wright patents. The negotiations were

long and tedious and he took the opportunity at the beginning of June to slip over to England from Berlin to help Ogilvie with his "Baby" Wright racer, fitted with a 40 h.p. N.E.C. two-stroke engine.

While practising, with Wilbur watching, at Eastchurch, the magneto became retarded, of itself, and Ogilvie had to make a forced landing. At the moment of trying to do so he was over the rough road which ran across the aerodrome at Eastchurch and was heading straight for the pond. Trying to make the turn on the ground too quickly, one propeller touched and broke and the machine slewed round and broke off the tailplane and fell backwards on its trailing edge, in a cloud of dust. All that could be seen, for a moment or so, of Ogilvie, were his feet above the dust cloud, and Wilbur Wright made a very good story afterwards of the incident.

When Wilbur Wright was staying with Ogilvie, he insisted on taking a camp bed to the shed where the machine was, and sleeping there at night. It was characteristic of the man. During those days in France when he was showing the world how to fly, he slept in the hangar near his machine. Neither he nor his brother overlooked any detail when they were flying. No flight was ever made without the knowledge that every step and precaution which could be taken to make that flight safe had been taken.

On June 27 1911, after his return from Eastchurch to Berlin, Wilbur wrote to Griffith Brewer:

> "I reached Berlin this morning. . . . So far as I have learned nothing was done at the directors' meeting last week of such serious consequence as to make me regret that I stuck to Eastchurch instead of coming over here at that time. It was rather a risky thing to do, but I did not like to leave until I had seen the nature of the injury the 'baby' had suffered, and its proper repair."

It was a typical attitude of Wilbur's, however good

FIGURE 50. Wilbur Wright poses in France for his photograph!

the other man was, to see for himself and satisfy himself that all was done as he would have done it.

> "From a telegram just received from Mr. Ogilvie," he added in his letter, "I see the machine is about a mile and a half faster than with the 4-cylinder American motor. This accords with our calculations based on the standing tests of the speeds of the propellers indoors."

It was while carrying out a propeller test for Ogilvie, in the shed, that Wilbur lost his hat! (*see* page 806).

On July 4 he wrote again from Berlin, to Griffith Brewer.

> "According to the newspapers Mr. Ogilvie seems to have handled his machine very well, although I judge that the wind must have been pretty bad. The various Continental papers tell different stories on this point, but the fact that Mr. Ogilvie's speed was less

FIGURE 51. Postcard from the School of Aviation at Pau, signed by Wilbur and Orville Wright, showing Wilbur Wright in flight, February 1909.

than last year, although he had a machine a little faster than before, would seem to indicate that the wind was pretty bad. It was bad enough at Belmont Park during the last year's race."

Even Wilbur Wright could not deduce from foreign newspaper reports that after 21 laps of the course Ogilvie ran short of petrol and came down to refuel. The race was won by the Frenchman Weymann whose Nieuport was fitted with a 100 h.p. engine against Ogilvie's 40 h.p. N.E.C.

In September 1911 Ogilvie, who had now been elected a member of Council of the Aeronautical Society, again visited America at the invitation of Orville Wright, who not only wanted to try some soaring at Kitty Hawk, but was also in great need of a real holiday. These attempts at soaring were a new departure, which attracted a considerable publicity at the time, though it was not until some years after the First World War, in Germany, that they were followed up, and now soaring plays a not inconsiderable part in the understanding of movements of great masses of air.

With Ogilvie and Orville Wright were the latter's elder brother Lorin and a young nephew. A glider had been made at the Wright factory at Dayton and shipped to Kitty Hawk for the trials. The shed used three years previously was still standing. Parts of two old 1905 and 1908 machines were found in a crate and these proved of first-class use for supplying spare parts and making alterations. There were in fact two fairly serious smashes and these spares were invaluable.

FIGURE 52. Orville and Wilbur Wright outside a hangar at Brookham Park, New York, during the Gordon Bennett Race, 1910, in which Alexander Ogilvie took part.

	Standard Machine	*Racing Machine*
Span	39 ft.	20 ft. 6 in.
Chord	6 ft. 3 in.	3 ft. 6 in.
Gap	5 ft. 6 in.	3 ft. 6 in.
Area—main planes	475 sq. ft.	150 sq. ft.
Engine	35 h.p. (4 cyl.)	60 h.p. (8 cyl.)
Total weight	1320 lb.	900 lb.
Loading per h.p.	37·5 lb.	15 lb.
Loading per sq. ft.	2·75 lb.	6 lb.
Speed	38 m.p.h.	75 m.p.h.
Weight Details		
Structure	475 lb. = 36%	250 lb. = 28%
Engine rad. and water	285 } 12 lb. per h.p.	361 } 7½ lb. per h.p.
*Propellers, chains, etc.	132 }	87 }
Fuel and tank	84 (10 gal.)	74 (9 gal.)
Crew	344 (2)	128 (1)
Total	1320 lb.	900 lb.

* Same type of propeller was used for both machines.

FIGURE 53. Comparison of Wright aeroplanes.

The first glides showed at once that the control surfaces were too small.

"Rear elevator too small," reads Ogilvie's diary on October 16th, "One bad bump, bending back centre uprights. Vertical rudder not very effective, better after fixing vane in front. Took glider to Kill Devil Hill. Glide by O.W. Landed on hummock and was chucked out."

It is interesting to compare Orville Wright's diary* for the same day:

"Kill Devil Hill: After one glide, in which I pitched forward out of the machine, put on large rudder, 38″ by 8′ 10″, using center of 1905 rudder. Afterward made glide of 637 ft. in curved line, 568 ft. in straight line. Angle 7° 45′. Wind very light (4 mi.). Time 23 secs."

Ogilvie's figures agree, naturally, with those recorded by Orville Wright, but he added the additional information that the glide began at a height of 92 ft., that is eleven feet from the top of Kill Devil Hill. The first 14 feet down the slope of the hill was an assisted take-off, and the air speed was 22½ m.p.h.

The winds were fairly steady, as there was the Atlantic on one side of the narrow strip of sand and a wide lagoon on the other, with no obstructions except the two smooth cones of sand—West Hill (80 ft.) and Kill Devil Hill (103 ft.). Ogilvie had brought out a Negretti anemometer and took many readings which showed that during the visit the wind on the level would rise from a calm to 25 m.p.h. and back to a calm in a sequence of five days.

On the top of Kill Devil Hill the wind would be 40 m.p.h. when it was 20 m.p.h. at ground level. At the leeward side of the hill the sand fell away sharply and there was a dangerous down draught.

Ogilvie records that it was found that to soar required a wind at the top of the hill of 25 m.p.h., and that it was extremely difficult flying and required a lot more control than was available on the earlier

* Not made public until December 1953. *See* Reference No. 32.

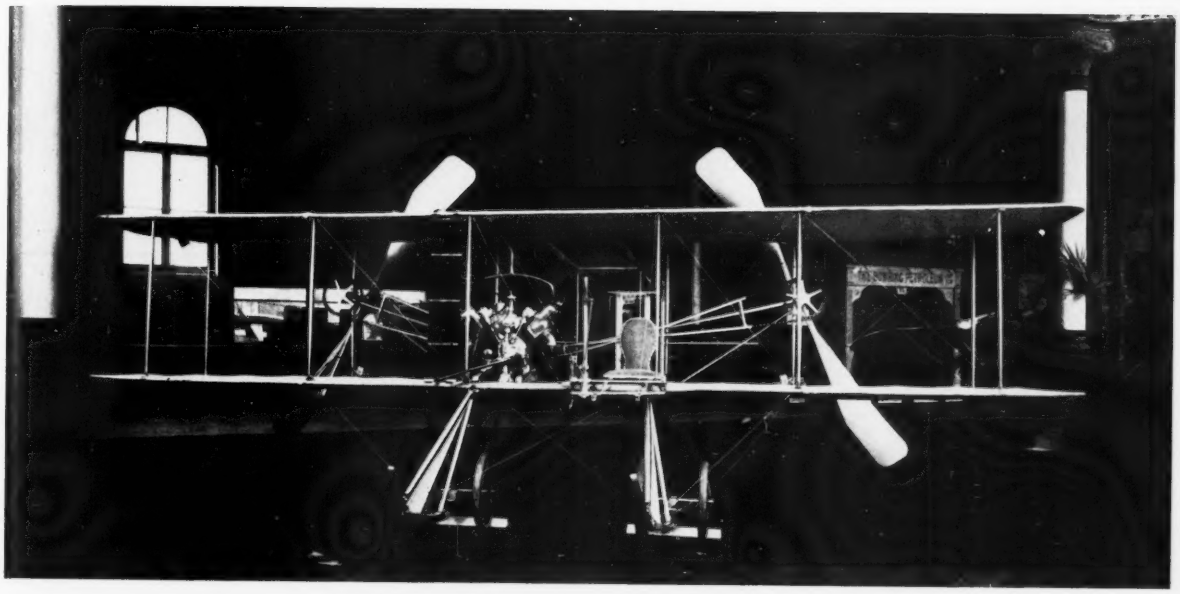


FIGURE 54. Ogilvie's Wright racer at Eastchurch, 1911.

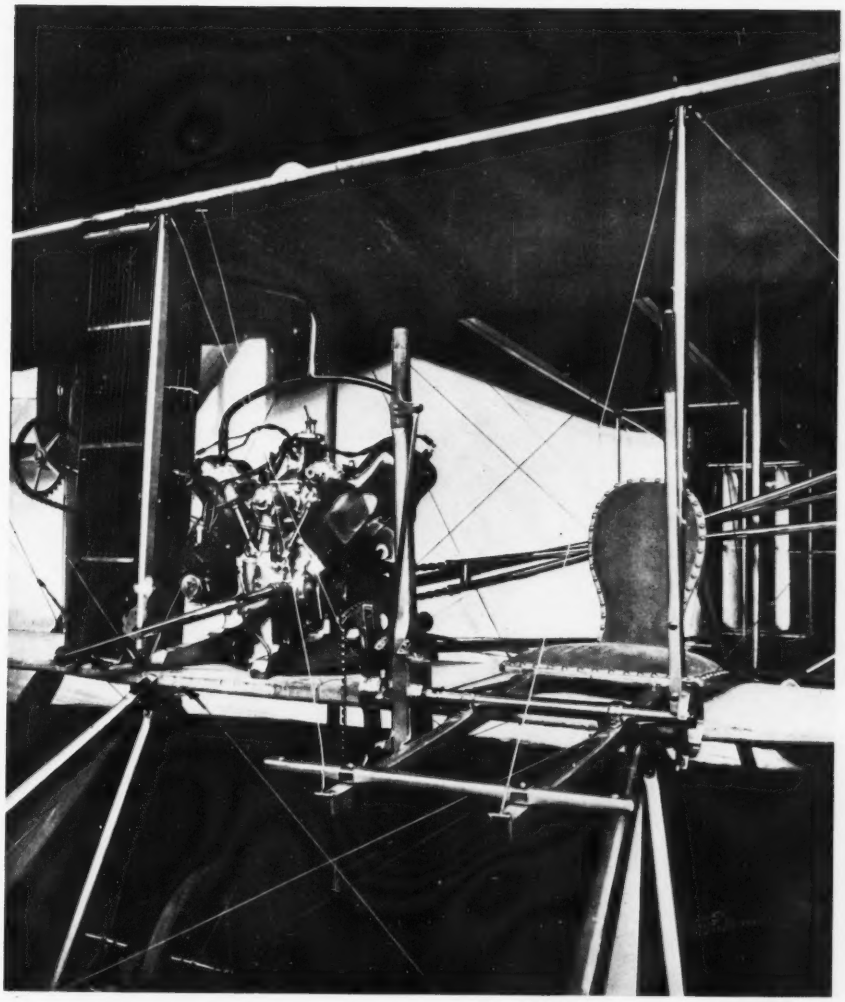
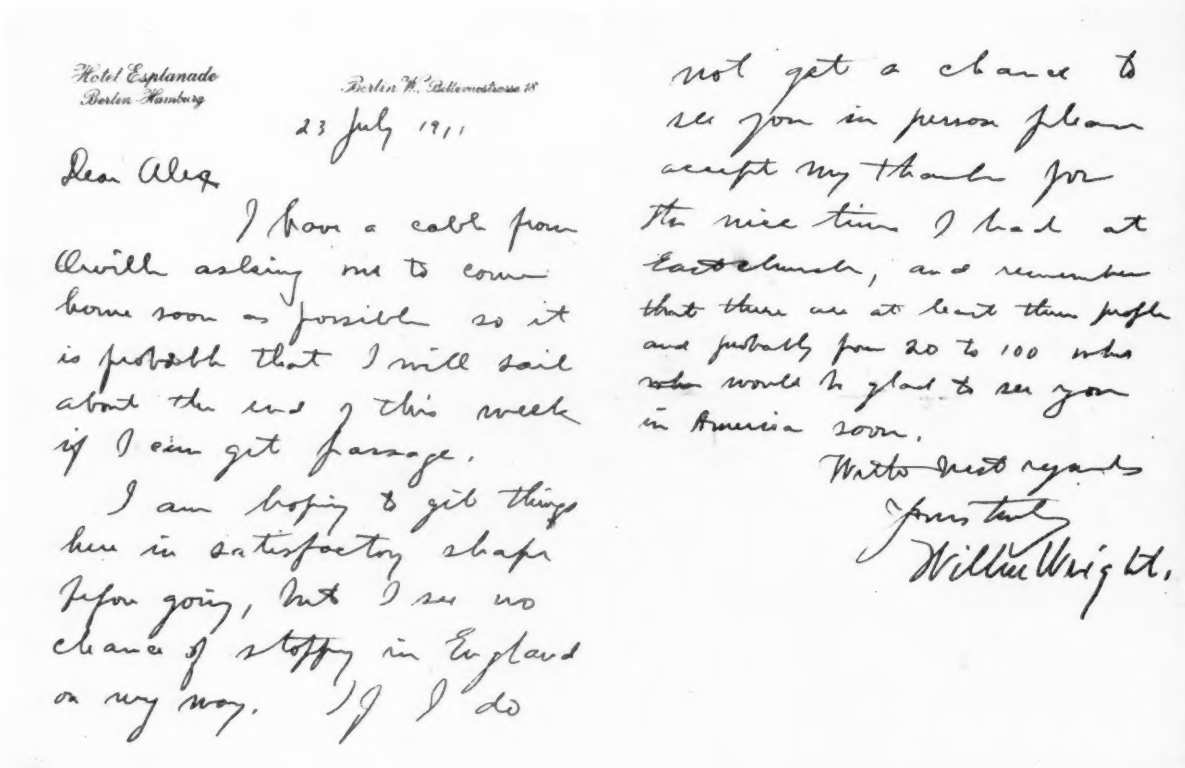


FIGURE 55. Ogilvie's Wright racer at Eastchurch, 1911, showing the New Engine Company's 4-cylinder 2-stroke engine of 40 h.p. Note the Orville Wright system of lateral control lever. The lever for the left hand is the elevator control with friction brakes.

FIGURE 56. Orville Wright (with cap) and Alexander Ogilvie building up a glider at Kitty Hawk, 1911.



Hotel Esplanade
Berlin-Hamburg

Berlin W. Tellowstrasse 28

23 July 1911

Dear Alex

I have a cable from Orville asking me to come home soon as possible so it is probable that I will sail about the end of this week if I can get passage.

I am hoping to get things here in satisfactory shape before going, but I see no chance of stopping in England on my way. If I do not get a chance to see you in person please accept my thanks for the nice time I had at Eastchurch, and remember that there are at least three people and probably from 20 to 100 who would be glad to see you in America soon.

With best regards

Yours truly

Wilbur Wright.

FIGURE 57. Autograph letter from Wilbur Wright to Alexander Ogilvie, following his visit to Eastchurch.

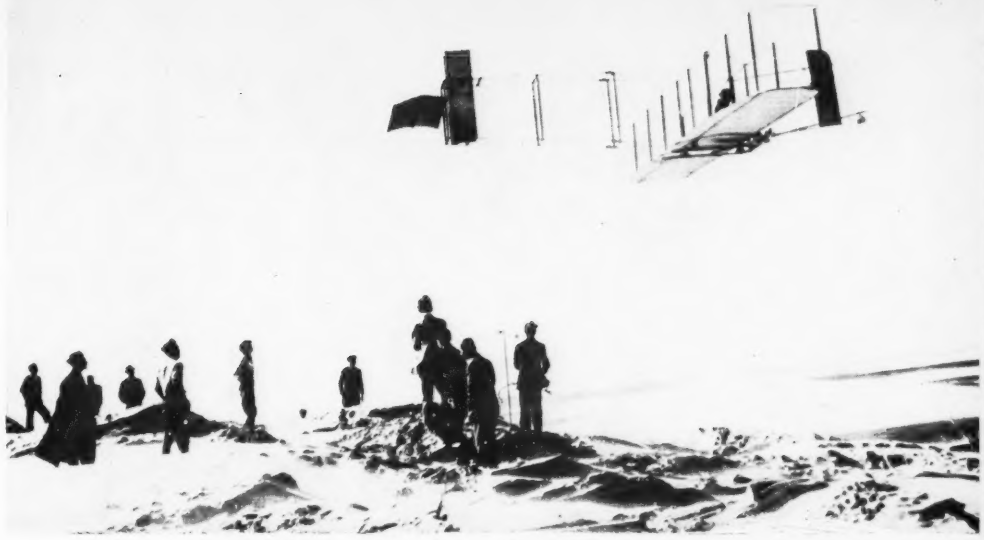


FIGURE 58. Orville Wright making a world's record for soaring flight of 10 min. 1 sec. east of Kill Devil Hill.

gliders. It was also very difficult for the pilot when soaring to keep track of where he was relative to the hill, which vanished as soon as he was air borne.

A number of soaring flights were made, one by Orville being the longest, of about ten minutes, and Ogilvie's of one minute. Here is the entry from Ogilvie's diary for October 24 1911.

> "20-25 m. wind. Fine and sunny. Successful soaring up to 10 min. by O.W. Others 7¼′ and 5′ aggregating nearly one hour. Only just enough control. Very difficult. I did a few glides late in afternoon. M/c travelled 40 yards without loss of speed on 6° slope. Wind condition: On crest 40 m.p.h., 12 ft. up 50 m.p.h. Just below crest 30-35 m.p.h. O.W. was sometime 50 ft. above top of hill. (*See* Fig. 58).

Kitty Hawk was not quite the deserted spot it was in December 1903. The Wrights were news and a number of reporters turned up to see what fresh ideas there might be flying around. Orville had a sense of humour which he let play on this occasion.

The reporters noted one day that a rod projected from the leading edge of the glider, with what looked like a bag tied on the end. When they asked Orville what was the use of it, he replied: "It's a special stabilising device," and the news went round that a new method of ensuring the stability of an aeroplane was being tried out at Kitty Hawk, the details of which were still secret. References to the diaries of Orville Wright and Ogilvie read: "Hung 8 lbs. sand 7 ft. out" (O.W.) or: "Weight of 12 lb. 8 ft. from front edge" (A.O.). These bags of sand were hung on merely to bring the centre of gravity of the machine forward! (*See* Fig. 60.)

As a sideline to soaring Orville showed what a good mechanic he was by taking Ogilvie's watch to pieces, urged on by the owner finding sand had stopped the works, and replacing the parts in going order. It isn't everyone, outside the watchmaking industry, who could have put all the parts back again.

Of Orville, Ogilvie wrote:

> "He was the life and soul of the party, kind and considerate. He did most of the cooking and obviously was enjoying himself very much. The difficulties of the job stimulated his energies and he was not in the least disturbed in mind or body by any of the accidents in the course of which he was thrown out of the machine three times.
>
> "No work was done on Sundays."

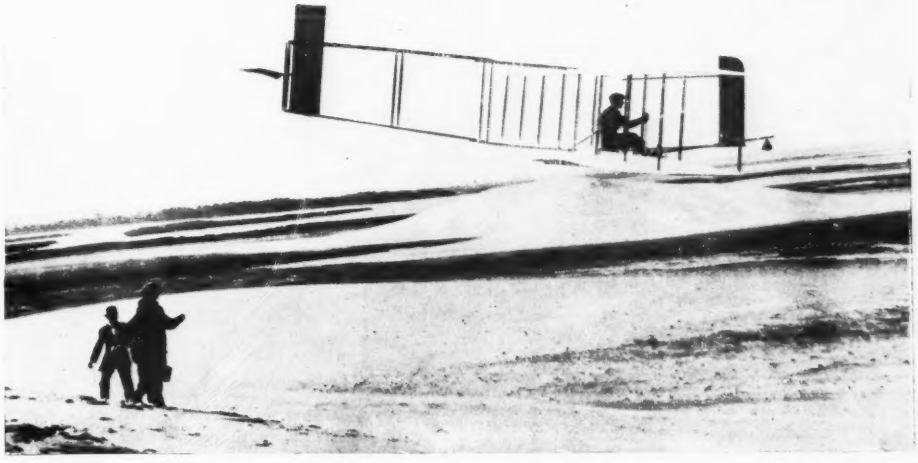


FIGURE 59. Alexander Ogilvie soaring at Kitty Hawk 1911. Note sand cup on leeward side of the hill.

FIGURE 60. Orville Wright gliding at Kill Devil Hill. Note "secret" stability device.

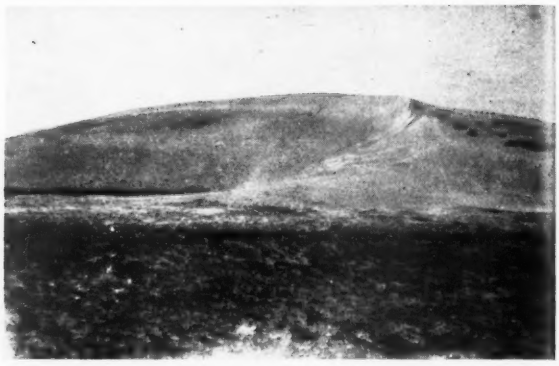


FIGURE 61. Kill Devil Hill.

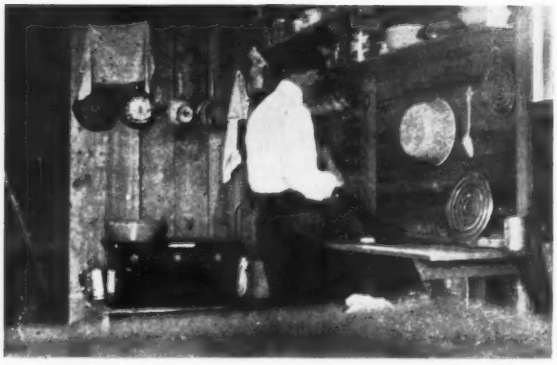


FIGURE 62. Orville Wright officiating in the kitchen, Kitty Hawk, 1911.

FIGURE 63. Orville and Wilbur Wright with their pilots, Walter Brookins, the first to be trained, Frank T. Coffyn and Roy Knabenshue, Manager of the Wright school, at Dayton, 1911.

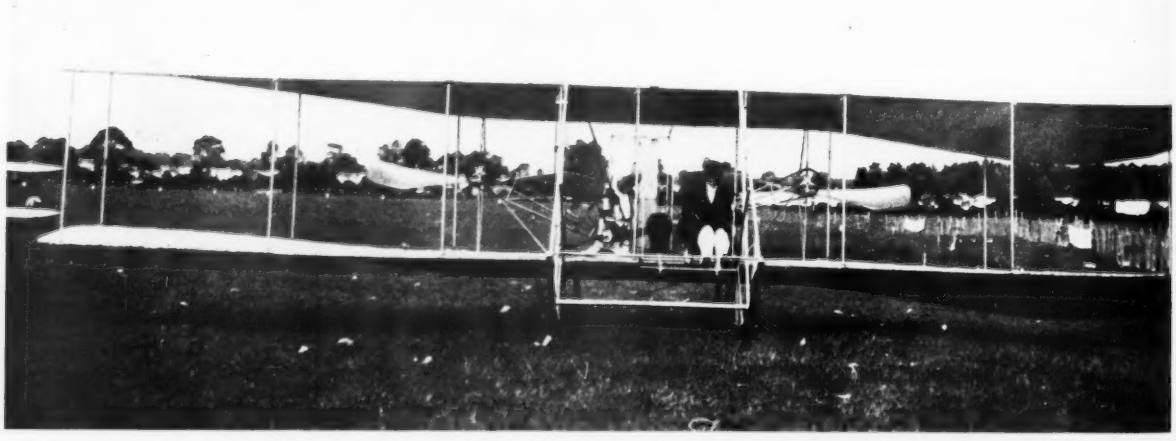


FIGURE 64. Arch Hoxsey, one of the early American pilots, demonstrating the warping of the wings on a Wright aeroplane.

Years of Disparagement, 1914 - 1942

"A merciful Providence fashioned us holler
O' purpose that we might our principles swaller."
James Russell Lowell.

From 1910 to 1914 Griffith Brewer paid regular visits to Dayton.

On his way to Dayton in May 1914 he passed through Washington and paid a visit to the Smithsonian Institution. To his surprise he found that the Langley machine which had been launched twice, unsuccessfully, in 1903, the second time only nine days before the Wrights flew, was not on show. He was told that it had been taken to Hammondsport where fresh trials were being carried out.

"I told Orville of my visit," wrote Griffith Brewer in his book *Fifty Years of Flying*, "and I then learned that there had been some propaganda in the American Press tending to belittle the Wrights' work and to suggest that Langley would have succeeded in flying if it had not been that his machine caught in the launching gear when being catapulted off the top of the houseboat. Seeing that the experiments with the Langley machine were being made at Hammondsport under Glenn Curtiss' direction, it seemed possible that some endeavour was being made to show that the Wrights were not pioneers in flying because of Langley's earlier work. . . .

"I must have bothered Orville a good deal about the book I had come to America to write and also with my desire to fly, and in order to put me off he said that if I wanted to get busy I might do better work by going to Hammondsport and seeing what they were doing with the Langley machine. I fell in with this suggestion and went off to Hammondsport, feeling rather like a detective going into a hostile country, where I should get a rough handling if my mission were known.

"Glenn Curtiss and Zahm were fitting the Langley machine with floats. . . . I wrote a letter from Hammondsport to the *New York Times*, in which I enumerated some of the changes being made in the Langley machine. That letter was published on the 22nd June 1914. I then returned to Dayton to take up my flying instruction."

It was over seven years before Brewer could continue the attack he had started, for the first World War intervened.

The *New York Times* published his long letter in full and drew attention to the fact that he was a member of Council of the Aeronautical Society and a member of the Committee of the Royal Aero Club.

After giving a list of the alterations made to the Langley machine, he said in his letter:

"Why, in view of all these facts, are the American newspapers making such a fuss of what Langley might have done had his machine been built differently and had he known more facts on the subject of flying?

"Why has Langley's most interesting machine been taken out of the Smithsonian Institution and altered from its original historic state to try to make it fly?

"Why, if such a demonstration were considered desirable, was not the old historic relic left untouched and a copy made to satisfy an insane curiosity? . . .

"All these things are incomprehensible to me, especially as I have just arrived from England, where the Aeronautical Society of Great Britain has only last month been paying its annual tribute to the memory of its honoured member, the late Wilbur Wright, whom it regards as the joint inventor with his brother Orville of the first actual flying machine."

Griffith Brewer could do no more then. He took his flying certificate at the Wright school at Dayton and returned to England.

While the First World War was raging the Smithsonian Institution issued in 1915 its report for the previous year's activities. It contained a report by A. F. Zahm which was headed: "The first man-carrying aeroplane capable of sustained free flight: Langley's success as a pioneer in Aviation." This report was issued later by the Smithsonian as Publication 2329.

This paper by Zahm, who acted as official observer on behalf of the Smithsonian, gave detailed statements of the success of the experiments with the Langley 1903 machine at Hammondsport in June and September 1914. He asserted that the machine as flown at Hammondsport in June was substantially as it had been in 1903, with the exception of floats and trussing to test it from the water. How untrue Zahm's statement was and how many bitter years passed before it was withdrawn is told in the following pages of these years of disparagement.

In 1916 Griffith Brewer gave the Fourth Wilbur Wright Memorial Lecture on "The Life and Work of Wilbur Wright." It was comprehensive and was a favourable opportunity to give a more accurate picture of the work of Wilbur Wright than had up to then appeared. It has been freely quoted from in this paper.

In seconding the vote of thanks on the occasion, Lord Northcliffe said, among other things:

"There is one point to which Mr. Griffith Brewer did not call attention, and that is the attempt that has been made to rob the Wright Brothers of the credit of their invention. We have not heard much of that in England, but 'a prophet is not without honour save in his own country,' and in the United States there have been long and persistent attempts to belittle the work of Wilbur and Orville Wright. . . .

"I never knew a more simple, unaffected trio than Wilbur, Orville and Katharine. After they had been in Europe a few weeks, they became world heroes, and when they went to Pau their demonstrations were visited by thousands of people from all parts of Europe—by kings, and lesser men—but I don't think the excitement and interest produced by their extraordinary feat had any effect on that simple American trio at all. I had from Katharine a fortnight ago, just the same simple kind of letter which one friend writes to another, and the only remark she made about the great work they had done, was to call my attention to

FIGURE 65. Orville Wright and Griffith Brewer at Huffman Prairie, Dayton, 1914.

two or three of these American attempts to deprive the brothers of the credit which belongs to them on account of their efforts. . . . Their heads were not in the least turned by the various attentions bestowed on them, nor by the many great financial offers given them to make demonstrations.

"I wrote to Mr. Griffith Brewer a few months ago saying that in accepting £15,000 for inventions valuable to this country, not only as a source of industry and a means of living for scores of thousands of our people, but as probably the greatest means of defence of this island in the future, the Wrights acted nobly. I think everyone will agree with me that these two brothers did behave in a splendid and handsome manner to Great Britain.

"They were Americans of English descent, and had a great affection for this country, and their sister, in writing to me the other day, said: 'We here make no pretence at being neutral—we are heart and soul for England and her Allies in this great struggle,' and I think that family proved it by taking a beggarly sum for one of the greatest inventions of the world."

It was Katharine Wright who wrote to Brewer in November 1920 when Brewer wanted to prepare a book by various authors on the history of attempts to fly, leading up to the actual success of the Wrights:

"Why don't you go ahead and use your main time and energy telling what Will's and Orv's work was and let your readers draw their own conclusions? When you tell how the first machine was calculated; the laboratory work that was done; the accuracy of the results, etc., etc., the reader won't get the impression that it was a matter of luck or agility of limb that made Will and Orv make the first flying machine and fly it as Lord Northcliffe said. And you won't be discrediting any one who went before either. You can tell—in words which they themselves used at the time from letters, etc., what *they* thought their indebtedness was. I've such stacks of interesting letters and telegrams and all that sort of thing which is a much more convincing record of what everyone was thinking *at the time* not now after all the controversy and what different motives enter in. For instance Orv has letters and telegrams from Langley in 1903 showing that Langley thought they were ahead of him then. Let's get these published and let people see how different it all was *before any one flew*. . . . You can quote Langley—not print what Dr. Walcott may say Langley thought or said or what he may twist around or assert *without proof*. . . . Something must be done to get the thing straight in history."

On October 20 1921 that something was done—and well done—by Griffith Brewer, in his lecture "The Langley Machine and the Hammondsport Trials." The Council made the decision to allow the paper to be read, after one of its committees had referred the suggestion to the Council that such a paper should be read to the Society. It was agreed that before the date of the lecture anyone attacked in it should have a copy of the lecture beforehand in time to reply to what would be said at the time of the lecture's delivery. The paper was vetted by Orville Wright, who added corrections and comments before it was printed.

Griffith Brewer himself wrote of the situation at the time:

"I found that the campaign of belittling the Wrights was still on, and from time to time in my visits in 1919 and 1920 I heard of indignant Americans who set about exposing the destructive propaganda of the Smithsonian. Each champion of truth sooner or later dropped his dangerous investigation. Such people realised that, seeing the Smithsonian was the leading scientific authority, anyone attacking that body would do so with the disapproval of orthodox science in America."

The paper rightly caused a furore and leading articles appeared in many of the principal papers in Great Britain and America. The attitude taken up by orthodox science on both sides of the Atlantic was very much what Griffith Brewer had predicted.

His charge was perfectly straightforward and simple.

"I have recently returned from a further investigation in America, and I am now in a position to report to this Society . . . that the Hammondsport trials have been inaccurately reported to the Smithsonian Institution.

"The Smithsonian Institution has always attributed the failure of the Langley machine in 1903 to a failure in the launching apparatus, and it has hitherto been generally accepted that the machine was wrecked without having had an opportunity to prove whether it was capable of flight. It is easy, therefore, to understand that since the Wrights, who had been working on the same problem, succeeded where Langley had failed, Langley's friends eagerly welcomed the suggestion made ten years later that it might still be possible to prove that Langley's machine was capable of flight. . . ."

Looking back over the years it appears probable that Langley's successors, Dr. Walcott and Dr. Abbot, acted from a high motive, the belief that their predecessor as Secretary, who had spent so many years trying to solve the problem of flight, had only failed to do so by sheer bad luck when it came to the crucial moment of launching. But the whole of the evidence over the years has made it quite clear that the machine as built and launched in December 1903 was structurally incapable of flight. Dr. Walcott, Langley's immediate successor, made the inexcusable blunder of allowing the original machine to be taken out of the Smithsonian by a rival manufacturer to the Wrights and to appoint as the technical expert to watch the trials one who had already acted as a technical witness for Wrights' rivals.

Again I quote Brewer:

"In April 1914 the original Langley machine, which had collapsed on the two attempts to launch it in 1903, was sent by the Smithsonian Institution to the Curtiss Aviation Field at Hammondsport, N.Y., and entrusted to Mr. Glenn H. Curtiss. A modified machine was built up at Hammondsport, under the direction of Mr. Curtiss, and under the observation of Dr. Zahm, and flights were then attempted to be made with this Hammondsport machine. An official report, written by Dr. F. A. Zahm, was afterwards issued in 1915 by the Smithsonian Institution, proclaiming that flights had been made at Hammondsport, N.Y., in 1914, by the original Langley machine.

"The Hammondsport machine was afterwards returned to the Smithsonian Institution in Washington, D.C., and the original portions still remaining were utilised in the construction of a facsimile of the original Langley machine. This reconstructed machine is now exhibited in the U.S. National Museum with the following inscription:—

ORIGINAL LANGLEY FLYING MACHINE 1903
The first man-carrying aeroplane in the history of the world capable of sustained free flight. Invented, built, and tested over the Potomac River by Samuel Pierpont Langley in 1903. Successfully flown at Hammondsport, N.Y., June 2 1914.

"I am here today to show members of the Royal Aeronautical Society that both the Smithsonian Report and the inscription on the Langley machine are misleading and untrue. No attempt was made at Hammondsport to fly the original Langley machine. At Hammondsport fundamental aerodynamic alterations were made to the machine which were not mentioned in the report by Dr. Zahm to the Smithsonian Institution. This Hammondsport machine was then put through so-called flying tests, altered after almost every test, and the tests were reported as flights of the original Langley machine. The Smithsonian Institution was led to believe and falsely proclaim that Langley had succeeded, where in fact Langley knew that he had honourably failed."

That report of the Smithsonian misled many in America and in Great Britain, for it was difficult to believe that an Institution with as high a reputation as the Smithsonian would lend itself to the publication of false information. I was, myself, misled at the time, and wrote that Langley would have been able to claim to have been the first man to produce a man-carrying power-driven aeroplane if it had not been for the unfortunate accidents in launching. The statement even got into a Wilbur Wright lecture, before Brewer's statements, as well as in a number of books and papers dealing with the history of aviation.

In his paper Brewer listed fifteen major alterations and summarised his paper:

"It is untrue to say that Langley's machine of 1903 ever has flown or ever could fly. In both trials

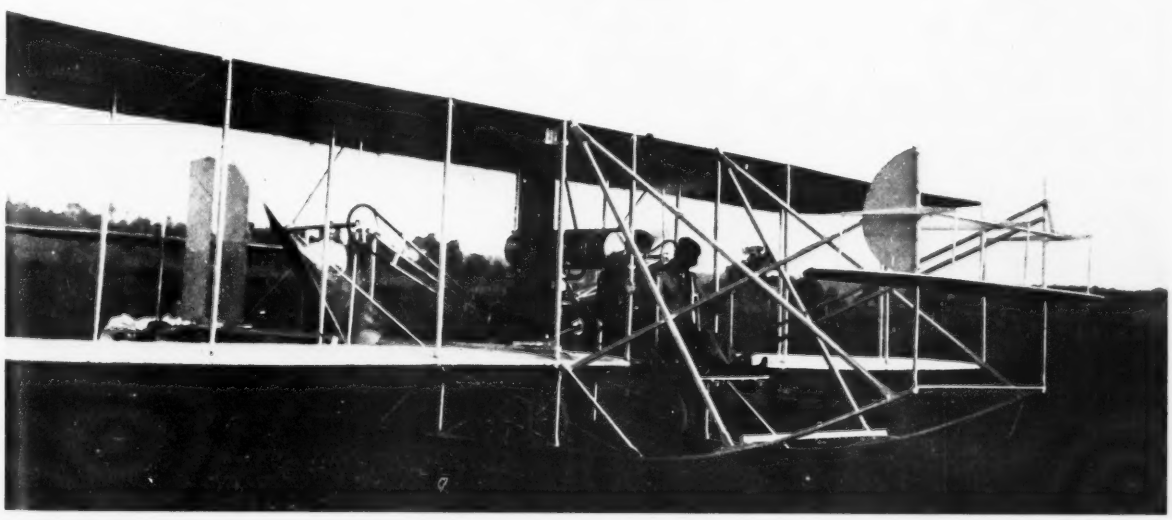


FIGURE 66. Griffith Brewer ready to take his first instruction as a pilot, at Dayton, 1914. For 250 dollars he was entitled to 4 hours of training flights. In the Agreement he absolved the Wright Company for any personal injury he sustained, and they were responsible for breakage of the machine. A lesson was stated to "consist of one flight of 15 minutes or more duration."

in 1903 the wings collapsed through faults in design of the machine, and not from any failure in the launching mechanism.

"The machine used at Hammondsport in 1914 differed from the original Langley machine in many important respects.

"The wings were of different area, different camber and different aspect ratio.

"The system of wing trussing, which in the Langley machine had failed, was completely changed at Hammondsport.

"The large keel surface of the Langley machine was altogether omitted.

"The Langley system of launching was abandoned, and a system developed after his death was used in its place.

"The original Langley propellers were modified and afterwards superseded by a modern propeller, based on knowledge not possessed by Langley.

"A system of lateral control unknown to Langley was added. The dihedral angle of the wings on which Langley relied entirely for maintaining lateral balance was supplemented in the Hammondsport machine by the action of a rudder of increased size used as an aileron.

"The steering wheel, post and shoulder yoke of a modern Curtiss machine were installed complete in the Hammondsport machine.

"The original Langley engine of 52 h.p. was at first modified and afterwards superseded by a modern Curtiss motor of 80-100 h.p.

"At first it was necessary to change the machine to carry the engine, and then it was necessary to change the engine to carry the machine. Finally there was neither the original Langley engine nor the original Langley machine.

"The remains of the Langley machine were at last returned to the Smithsonian, and were entrusted to Mr. Reed for restoration to the original form of 1903. Mr. Reed did his work well, for when I saw the rebuilt Langley in the National Museum last April, it was very much like Langley had built it. The wings had their leading edges restored, thus bringing them back to their former camber and area; the wings were stayed to the old guy posts, which were set forward again to their original but ineffective positions; the Langley propellers were restored; the pilot's car was again under the forward part of the frame, the Curtiss control gear had been removed. In fact the whole machine had lost all appearance of having been out on an indiscreet adventure.

"The present paper, however, does not deal with Langley's work except so far as is necessary to disprove the wild assertions made by pretended friends in order to build up for their own ends a credit for Langley which could not be enduring, a credit which Langley would be the first to repudiate, were he here to do so. No fraud can long endure when so much evidence is on record."

The sad and bitter thing is that the fraud endured for twenty-eight years before it was fully acknowledged that everything Brewer had so courageously asserted (and more in fact) was fully justified.

The Council of the Society had insisted that advance proofs of the paper should be sent to the Secretary of the Smithsonian, Dr. Walcott, to Dr. A. F. Zahm, the technical representative at the trials, to Mr. C. M. Manly, designer of the engine for the Langley machine, and to Mr. Glenn H. Curtiss. Their comments were printed in full after the lecture, in the Society's JOURNAL.

Dr. Walcott dodged the real gravamen of Griffith Brewer's charge, which was that the Langley machine was incapable of flight, either structurally or aerodynamically, and had been altered in a number of ways to enable it to make a flight.

> "I take pleasure in saying at the start," wrote Dr. Walcott, "that the Smithsonian Institution fully recognises the well-deserved success of the Wright Brothers in being the first to make actual flights in heavier-than-air power propelled machines. This recognition the Institution was among the earliest to make in a formal manner by an award of merit."

Walcott continued: "This being so, I am not prepared to concede that the Wrights were the first to construct such a machine capable of such flight."

That last sentence was as definite as it could be that the Langley machine was the first one capable of flight. Walcott did not deny Brewer's charges of structural alterations, but belittled their importance.

Griffith Brewer was severe in his reply.

> "As Dr. Walcott does not specifically deny a single one of the changes which I have enumerated in my paper, I think I am correctly giving the gist of his reply when I say he expresses the belief, that because a machine with wings more roughly built and having a different camber, different system of launching, different system of trussing, different weight, modified propellers, modified controls and with a modified motor had succeeded in getting off the water for approximately five seconds, therefore the original Langley machine of the original design and the original construction *should* be able to fly."

Dr. Zahm took up an attitude of injured innocence.

> "To impugn the motives of the Smithsonian men associated with the work of retesting the Langley machine in 1914," he wrote to the Secretary of the Society, "is a discourtesy and injustice that well might be discountenanced by an impartial society. Aside from the innuendoes and direct imputations, is it quite decorous to regale an honourable body of men with isolated bits of testimony selected from a compromised patent unit by a special pleader who paid a friendly visit to the complainant but failed to interview the accused? Surely the members of a royal society cannot relish the false report of a partisan member upon the financial conduct of an honoured institution of a friendly nation."

Zahm challenged the truth of Brewer's statements, although admitting changes had been made in the Langley machine, and ended his long letter:

"It seems superfluous to notice seriatim all the trivial differences a hardware clerk can find between the Langley aeroplane of 1903 and that of 1914. Multitudinous, minute, inconsequential, they read like a laundry list. And if a thousand objections were answered, a thousand more would follow. In the list of changes why should the colour escape attention? A canary yellow wing differs from a faded buff. The objections so far offered have little cogency, for they are mainly declaratory and statistical. They are the objections of a bookkeeper rather than of an engineer. But they doubtless have as much potency as the arguments of those mighty mathematicians who used to prove the impossibility of sustained free flight in any possible aeroplane of man's contrivance. And they have the merit of separating Langley's upright life from association with anything which is not strictly true or honourable."

Zahm added an Epilogue.

"The foregoing paper, prepared by invitation of the Council of the Royal Aeronautical Society, was forwarded to the Secretary with the following recommendation: 'Permit me very respectfully to recommend to the Council that it rigorously delete from the papers presented in this case, pro and con, all harsh personalities, all innuendoes, and imputations of bad faith, and distasteful to the urbane and cultured audience of a royal society."

Manly, who had acted as pilot of the Langley machine in 1903, gave reasons why he believed the machine had failed purely due to an accident of the launching gear. Manly was responsible for designing the engine, perhaps the most remarkable engine of its time, incorporating much that was not common practice for a score of years later.

Manly remarked that Brewer's paper reminded him of the great similarity in contents to the statements made in an affidavit by Orville Wright in the patent action against the Curtiss Aeroplane Company,

"In which Mr. Wright claimed for himself and his brother credit for everything 'that had been achieved in aviation from the beginning of time,' and had dismissed everything that went before as 'mere speculation and theorising.' . . . In fact it appears upon a review of this affidavit of Mr. Orville Wright, that the present paper by Mr. Brewer is merely a condensed statement of the assertions, arguments, speculations and errors of this affidavit by Mr. Wright."

Manly, nevertheless, added his felicitations to Walcott's that the Wrights had made the first flight.

"I do deny, however, that the machine which they built and with which they accomplished the first flight was the first full-sized machine capable of controlled flight, and I do assert that the Langley machine, which was built prior to theirs, was capable of successfully transporting a human being through the air and being controlled in such flight."

That was specific enough and one has little doubt that Manly sincerely believed what he asserted.

Glenn Curtiss was even more definite than Walcott, Manly and Zahm.

"I have always thought the Wrights are entitled to and have received full credit for having invented and built the first airplane to make successful flights. The Langley Flying Machine of 1903 *did* however fly in 1914 at Hammondsport, N.Y., in its original condition with its original motor and propellers with no alterations except the addition of floats and their necessary supports, weighing altogether 350 lb. . . . The facts are that the Langley machine was not only flown with the same identical motor, wing surfaces and general construction, but carried an additional weight of 350 lb. and still further with increased motor power it flew and carried an added weight of 800 lb. including the extra weight of the motor."

Very rightly Griffith Brewer commented:

"I was not content in my paper to merely deny this statement which Mr. Curtiss has made many times before, but I produced photographs and other proof to show that the Hammondsport machine was not the Langley machine with merely these differences, and I also submitted proof that even with this amount of changing the machine did not fly. Mr. Curtiss' flat contradiction of the photographs given in my paper carries no weight, especially as Dr. Walcott, Dr. Zahm and Mr. Manly acknowledge the changes and do not support him in this contradiction."

From any point of view Brewer's accusations against the Smithsonian deserved a better answer than mere denials and assertions, and would have received it, indeed, if the Institution had had any case, for it was in an extremely powerful position to refute Brewer's charges, if they were not true. The governing body of the Smithsonian included some of the most influential individuals in the American political, judicial and scientific scenes. The plain fact is that the Smithsonian officials could not produce a better answer. It was not until 1942 that the Smithsonian admitted the truth that one man's courage had enabled to be asserted so clearly and in the face of the vested interests of a very unhappy and very powerful kind.

The Times, in its leader the morning after the lecture, showed it had no doubts of Brewer's statements.

"His report is grave and convincing. He is able to bring forward indisputable evidence that the Langley aeroplane failed, not from defects in the launching machinery, but from ignorance of a fundamental principle of aeroplane construction first discovered by the Wrights and announced by them in 1901. . . . He uses strong words in his description of what he has discovered, words plainly inspired by a natural and well-founded indignation. We cannot doubt but that he has securely re-established the claim of the Wrights to be the true pioneers of aeroplane flight, and refuted the posthumous claim made for Langley. Nor can we doubt but that the Smithsonian Institution will lose no time in abandoning the position into which they have been misled."

Engineering, in its editorial on October 28 1921, voiced exactly the same opinion.

"From the evidence given in Mr. Brewer's paper it certainly would appear that this contention must be correct, and unless the statements made are capable of some altogether unexpected explanation, we feel confident that, in the interests of the history of science, the Smithsonian Institution will take early steps to remove the erroneous impression created by its report of 1915."

Nature in its leading articles, as was to be expected, defended the Smithsonian. In the light of present day knowledge it is understandable that the leader writer should say, in reply to Brewer's protest: "It is surprising to hear that 'the Wright Brothers first established a scientific basis for aeroplane design' and that their laboratory measurements 'covered a field many times greater than had been covered by the work of all other experimenters together.'"

The wind tunnel results and data of other experiments were not made publicly available and this secrecy, for sound enough reasons from the point of view of the brothers at the time, led to a misunderstanding and misinterpretation not only by the leader writer of *Nature* but by many others—as secrecy always does.

"Is it then strange," said *Nature*, "that one should look to Langley as the scientific pioneer, since he took the normal steps of a man of science and published complete accounts of his results as he obtained them?"

The present paper makes it abundantly clear what the Wrights actually did, experimentally, and what records they tabulated at the time. One may remark, nevertheless, that many scientific pioneers have failed to publish complete accounts of their results, for secrecy is often more commendable than the truth, the whole truth, and nothing but the truth. In this modern world truth lies buried deeply. Was it not Lanchester who said at a Society's lecture in 1917:

"He had heard it said that the Defence of the Realm Act permits anyone to tell falsehoods in public without fear of contradiction, and prevents anyone else from telling the truth without fear of finding himself in jail"?

Griffith Brewer was anxious to continue his correspondence with *Nature* but in all his actions where the Wrights were concerned he was meticulous in consulting them. Orville wrote in reply to his question, whether he should continue the controversy, "I do not think it advisable under the circumstances. The editor of *Nature* does not intend to allow you a fair chance. Therefore it is not advisable to carry on the discussion under these handicaps. . . . I cannot tell you how much I have appreciated the interest and the part you have taken in the Hammondsport matter."

Brewer accepted the advice given to him.

Katharine Wright was as energetic as her brothers in defending their claim and she wrote regularly to Brewer to give a picture of those who were helping "the cause" in America.

"Isn't it rich," she wrote, "how innocent Walcott and Zahm were of any idea that this Langley business might have something to do with the patent fight. The *N.Y. Tribune* correspondent says that 'for some reason or other the populace of Hammondsport feel that a successful flight of the Langley machine will give Curtiss an advantage over the Wrights.' . . . Everyone else knows what the object was except the Smithsonian! . . . But we will have a long hard fight before we compel the Smithsonian to make the thing right. But you have done one good job on that paper. Everyone thinks it is good. I hope it won't make you trouble. We don't say much about it but we do feel under great obligation. You are such a good friend!"

In a further letter from Dayton, dated January 7 1922, Katharine Wright wrote to Griffith Brewer,

"Of course we are having some ups and downs in the course of the fight. . . . The public now knows for the first time that there *were changes made*. We haven't convinced some of them that the changes were important but we will in time. People are now realizing that the two machines were contemporaneous. There has always been an impression that the Langley machine ante-dated the Wright by many

FIGURE 67. Orville Wright, Stefansson, Katharine Wright and Oswald Short, on the Wrights' porch, Dayton, 1922.

years—no one knew just how many years, but 'years.' In time we'll get all the facts established, thanks to you!"

Many believed Brewer's lecture was merely an ingenious way of giving wide publicity to him as a representative of the patent interests of the Wright Company. *Nature* wrote:

"The difficulty appears to arise from a not uncommon type of mental blindness which is readily produced by the contact of financial interests with development. . . . The transactions appear to have been rather sordid and to reflect discredit on the commercial systems of the world which exalt 'patentability' at the expense of solid service which is not patentable."

Brewer had no connection nor brief in any way for the American Wright Company and the British Wright patent, with which he was concerned, had expired four years before he gave his lecture.

Years of Honour, 1928 - 1948

"A prophet is not without honour save in his own country."

Matthew, XIII 57

It was only a matter of a few months after Brewer's lecture had been printed in the JOURNAL of the Society, and after he had sent several hundred marked copies to leading people in the United States at the suggestion of Orville Wright, that Brewer realised that the vested mental interests were more powerful than he had counted upon. There was no sign whatever that the Smithsonian were ready to withdraw their statements. While on a visit to Orville Wright in 1923, Brewer suggested that the Science Museum at South Kensington would be very glad to have an opportunity of taking care of and exhibiting the first machine to fly.

On November 13 1923 Orville Wright wrote the following letter:

"Dear Griff,

"Your suggestions with regard to the disposition of the 1903 machine have been thought over a good deal since you left. If you are right in thinking that the officers of the Museum would be keenly interested in securing this machine for exhibition in the Kensington Museum, I should be inclined to let them have it. The fire risks are too great where it is now stored and I have no better place for it.

"Of course the machine ought to be in the National Museum at Washington. But when one considers the way the officials of that Institution allowed the original Langley machine to be taken out of the Museum and the original materials of its structure to be destroyed for the purposes of private parties to a patent litigation, so that the machine now hanging in the museum is not the original but is mostly a new machine with many of the restored parts of different construction from the original; and when one further considers that they have hung upon this new machine a misleading label true neither of the new nor of the original machine, one can have little faith that our machine would be any safer from mutilation or that it would receive a label from the present officers of the Institution any more truthful than that on the Langley machine.

"If I were to receive a proposition from the officers of the Kensington Museum offering to provide our 1903 machine a permanent home in the Museum, I would accept the offer, with the understanding, however, that I would have the right to withdraw it at any time after five years, if some suitable place for its exhibition in America present itself.

Sincerely, Orville Wright."

The Director of the Science Museum at that time was Colonel H. G. Lyons, and his chief assistant on the aeronautical side was M. J. B. Davy, a Fellow of the Society.

Colonel Lyons acted promptly in accepting what he described in a letter to Brewer as "Mr. Wright's most generous offer."

Much turbulent water was to flow under the American bridges before the machine was actually safely housed at Kensington. Brewer went to Dayton in July 1924 and wrote to Lyons to say:

"The original machine is still packed in the light packing crates in Mr. Orville Wright's laboratory, where it has been undisturbed for several years. The delay in the machine coming to England is caused by the necessity of re-erecting the machine before disassembling for packing in stronger packing cases for shipment."

Any suggestion that the first aeroplane might leave America and be exhibited abroad had been carefully kept secret, but on April 30 1925, eighteen months after Orville Wright had made his offer, the *Dayton Journal* had a headline: "London Museum may get the first Wright aeroplane," and the American storm burst. There is nothing like the prospect of someone else getting what you don't want, for you to get busy explaining why you have always really wanted it!

The Dayton papers led the attack, demanding that Congress should intervene, castigating the Smithsonian, and publishing a long statement by Orville Wright saying exactly why he was sending the machine to London. Various Congressmen expressed astonishment at the charges being made. Most of the leading papers in America followed, though most seemed to be unaware of the lecture given before the Society by Brewer. The *New York Times* wrote: "Orville's desire to send the original plane to the Science Museum seems natural in view of the fact that he first received recognition in Great Britain," and gave the Royal Aeronautical Society the credit for recognising the brothers to be the first flyers. The *Kansas City Star* quoted Brewer at some length and in its editorial for May 18 1925 said:

"Fortunately the matter has been competently threshed out in England before the premier scientific body concerned with flight, the Royal Aeronautical Society. It was there shown that the final Langley experimental plane which fell into the Potomac was doomed to failure not because of any sudden gust of wind or other accident, but because Langley had failed to solve the theory of flight in three essential points."

Orville Wright wrote to Griffith Brewer on June 4 1925:

"I have been sending you some of the clippings from the American Press on the Smithsonian controversy. You will see from these that not many really understand the matter, but that a big row is being made over the machine going out of the country. One Congressman has threatened to introduce a Bill in Congress to prevent the exportation of such historic relics.

"This newspaper controversy has so interfered with my work that I cannot tell just when the machine will be ready for shipment. But I now think it will not be before October or November. I had hoped to get it out of the country before news of its going got out. . . . You will find in the clippings a good deal of talk about keeping the machine here. Tell Mr. Lyons to not let this talk disturb him. I have no intention of asking to be relieved of my obligation to the Science Museum. In fact I have no intention of ever having the machine come back here unless all of the sinister machinations of the Smithsonian are fully rebuked, and a sincere attempt is made to put the matter right. If requests should come from others to Mr. Lyons, he may be able to save himself embarrassment by answering that he leaves the matter entirely for my decision."

Progress on preparing the machine for shipment was agonisingly slow and even Griffith Brewer began to wonder if it would come to England in his lifetime. That was in December 1926.

Early in February 1927 Dr. Walcott died. He had held the post of Secretary to the Smithsonian for twenty years, and it was fully expected when the new Secretary, Dr. Abbot, was appointed that the Smithsonian would withdraw from the position it had held for so many years. But it did not do so.

Just a year after Walcott died Griffith Brewer received a cable: "Shipment left here for Minnewaska, sailing eleventh, letter will follow. Wright."

Orville Wright's letter to Brewer was to confirm the shipment of the aeroplane with instructions for its assembly. These instructions were extremely detailed. It is interesting to record one Orville Wright gave with regard to the rubber hose which was used to connect the petrol tank and the motor.

"We are no longer able to get in America tubing exactly that used in 1903. I am enclosing a short piece of the original hose which was still attached to the gasoline valve when we assembled the machine last year. This was the ordinary tubing used on bicycle tire foot pumps twenty-five years ago. The tubing for automobile pumps is much heavier. You may still be able to get tubing like the original in England, if not a substitute will have to be used."

Most of the American papers found it "a matter of real regret" that the first aeroplane to fly should have gone to England and the Smithsonian was severely taken to task for continuing to assert that the Langley machine antedated the Wright machine as far as capability of flight was concerned.

On March 4 1928 Abbot published the following:

"Elected in January to be Secretary of the Smithsonian Institution, I inherited a knotty problem, for February brought me face to face with the Wright controversy. On February 13 I wrote to Mr. Orville Wright: 'It would be a matter of great gratification to me and to all our countrymen if now, or even at a later time, you should see your way to depositing it (the Kitty Hawk machine) here.'

"On his part Mr. Wright had said that both he and his late brother wished to deposit the plane in the United States National Museum, but that it is now sent 'to the British National Museum because of the hostile and unfair attitude shown towards us by the officials of the Smithsonian Institution.' It is stated that the plane is still subject to recall. Since both Mr. Wright and the Smithsonian desire it, there remains only to come to just terms.

"The people of the United States, who support the National Museum, are vitally interested. They ardently desire that an object of such pride to all Americans as the Wright machine of 1903 should join the National Valhalla of aeronautics where rest so many planes that have made aviation history.

"I will not again present from the other point of view the questions recently raised by Mr. Orville Wright and his friends, for fixed opinions would remain unchanged. Braving warnings that whatever I now say will be misconstrued, I ask a fair hearing for the following offer:

"To make understood what I now propose, I must explain that the Langley machine of 1903 is now on exhibition in the National Museum with a label attached which was prepared in 1925, according to the advice of a committee. Two gentlemen from outside the Smithsonian, namely, Dr. Joseph S. Ames, of Johns Hopkins University, Baltimore, and Admiral David W. Taylor, United States Navy, who are now Chairman and Vice-Chairman respectively, of the U.S. National Advisory Committee for Aeronautics (of which body Mr. Orville Wright is also a member) formed the committee. At the late Secretary Walcott's request they examined the records of the Langley machine, including much unpublished correspondence, took testimony of experts, and presented a report which was given to the Press on June 9 1925. The label as revised to accord therewith now stands as follows:

LANGLEY AERODROME
THE ORIGINAL LANGLEY FLYING MACHINE
OF 1903, RESTORED

In the opinion of many competent to judge, this was the first heavier-than-air craft in the history of the world capable of sustained free flight under its own power, carrying a man.

This aircraft slightly antedated the machine designed and built by Wilbur and Orville Wright, which, on December 17 1903, was the first in the history of the world to accomplish sustained free flight under its own power, carrying a man.

(*There follows in small type accounts of the investigations of Langley and his machines, too long to quote here.*)

"I believe that label to be just, as do my colleagues, and cannot think that anyone would wish us to recant falsely. For the sake of the public I make the following offer.

"If Mr. Wright will openly state in a friendly way that he appreciates that the Smithsonian Institution honestly believes that the Langley machine of 1903 was capable of sustained free flight under its own power, carrying a man, and that it now removes that public statement, not in confession of error, but in a gesture of goodwill for the honor of America; then I am willing to let Langley's fame stand on its merits and to reduce the Langley label to this simple statement: 'Langley Aerodrome. The original Langley Flying Machine of 1903, Restored.'

"I will do this, of course, provided Mr. Wright will deposit the Kitty Hawk machine in the National Museum, where it has always been wanted, where it will have the place of honor due it, where the label will state that it was the first heavier-than-air craft in the history of the world to accomplish sustained free flight under its own power, carrying a man, and where it will be preserved inviolate to the Wrights' perpetual honor."

I published this statement in full in the JOURNAL for April 1928, together with the following letter from Griffith Brewer to me:

"I have to thank you for giving me the opportunity of commenting on Secretary C. G. Abbot's offer to Mr. Orville Wright, which has already been given wide publicity in the American Press. If similar publicity had been given to the report of Mr. Ames and Admiral Taylor, my report to the Royal Aeronautical Society of the change in the label on the Langley machine would not have been delayed until some months after the statement on the Langley label had been changed from a statement of fact to one of opinion.

"The present 'Offer' contains the first intimation of any enquiry based on testimony having taken place, and as readers of the JOURNAL of the Royal Aeronautical Society would naturally suppose that both sides in such an enquiry would have been invited to give evidence, I would say that until now I have never heard of any such enquiry having taken place.

"On the merits of the 'Offer' little need be said. It amounts to an invitation to Mr. Orville Wright to make an insincere statement, in return for which Dr. Abbot would withdraw the incorrect description on the Langley machine. Certainly Dr. Abbot only inherited this incorrect labelling of a Museum exhibit, and it has already been partly corrected. But why not complete the correction for the sake of truth, without bargaining? Griffith Brewer."

Orville Wright himself replied:

"This proposal does not correct the most serious things to which I have been raising my objections, which are predicated upon the false propaganda which has been issued in Smithsonian publications, in an attempt to take credit from us and give it to Professor Langley, a former secretary of the Smithsonian.

"Until the Smithsonian Institution expresses a willingness to make corrections of past misstatements I would not entertain any such proposal as Mr. Abbot suggests."

On March 23 1928 Brewer wrote to Orville Wright with the news of the opening of the new Science Museum building at South Kensington by King George V.

That day, for the first time, the British public were given the opportunity of seeing the first machine to fly. It was, indeed, the first time the public in any part of the world had seen the machine; save for those five people who saw it fly at Kitty Hawk on December 17 1903.

In the same month there appeared in the *United States Services Magazine* a paper by Orville Wright with the title "Why the 1903 Wright Airplane is sent to a British Museum."

The paper drew the attention of the American public to the constant misrepresentation of the Smithsonian Institution from the year 1910 up to the year the machine left for England.

"In sending our original 1903 machine to the Science Museum, London, I do so in the belief it will be impartially judged and will receive whatever credit it is entitled to. I regret more than anyone else that this course was necessary."

At the end of September 1928 the Smithsonian Institution published a report prepared by C. G. Abbot on the relations between the Institution and the Wright Brothers. This was a long report and in it he stated that the label on the Langley machine had been further modified to read:

LANGLEY AERODROME
The original Samuel Pierpont Langley Flying Machine of 1903, restored.
Deposited by The Smithsonian Institution.

so leaving out all the previous explanation.

In this report appeared that of Dr. J. S. Ames and Admiral D. W. Taylor which had caused the previous label to start with the words: "In the opinion of many competent to judge, this was the first heavier-than-air craft in the history of the world capable of sustained free flight under its own power, carrying a man."

Orville Wright was adamant that he would not let the machine be shown in the Smithsonian until it had publicly acknowledged the misrepresentations it had made over the years.

In 1933, five years after the machine had first been shown in the Science Museum, on the thirtieth anniversary of the first flight, Dr. Abbot again made an effort to get the machine, but without success.

With the outbreak of the Second World War in 1939 all the main exhibits in the Science Museum were packed away for safety, save the Wright machine which was left exactly where it was on the advice of Griffith

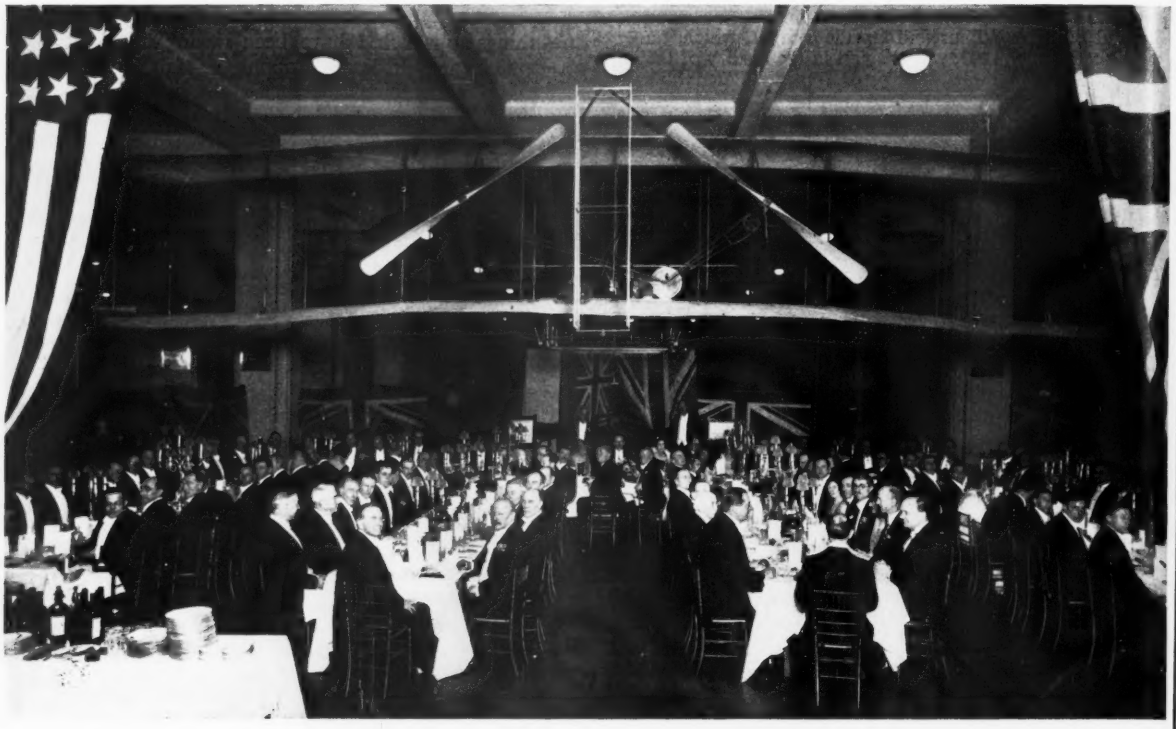


FIGURE 68. A Dinner held by the Royal Aeronautical Society on the 25th Anniversary of the First Flight, December 17 1928. The Dinner was held in the Science Museum under the original Wright machine.

Brewer, who wrote to Orville Wright that "the chances against a direct hit are about the same as the chances against anyone winning the Irish sweepstake on a single ticket." The machine was protected against blast in any event. But with the intensification of the War in 1940 the precious machine was packed and removed first to the basement of the building and later to a quarry in the West Country, some 100 feet below ground, where it was safe.

On October 24 1942 Dr. Abbot published his Report No. 3699 entitled "The 1914 tests of the Langley 'Aerodrome'" withdrawing all claims made for the Langley machine, and acknowledging the misrepresentations which had been made. The Report is reproduced in facsimile on pages 813-817.

On December 8 1943 Orville Wright wrote* to Colonel Mackintosh, the Director of the Science Museum, to say that he had decided that the Kitty Hawk machine should be returned to America "when transportation is less hazardous." He added:

> "I appreciate the great trouble the plane has been to the Museum under war conditions, and I am grateful for the unusual care the Museum has taken for the plane's safety.
>
> "It has been suggested that I permit the plane to be retained and again to be exhibited in the Museum for six months after the war is over while a copy is being made. I think this will be agreeable to me. But before the construction of a copy is started I would suggest that another set of the drawings made by the Museum in 1928 be sent to me for correction. I have found in your drawings a number of structural details that need correction, especially in places where details could not be seen by the draftsmen without a complete tearing down of the machine. The right side actually is four inches longer than the left. A draftsman for the United States Army some years ago made this same mistake. I have complete and accurate drawings of the engine and shall be glad to furnish them if you decide to make a replica. I also have the

FIGURE 69. Griffith Brewer, Henry Ford, and Orville Wright at the dedication of the Wright Homestead at Greenfield Village, April 1938.

* Letter quoted in Kelly's *Miracle at Kitty Hawk*.

patterns from which the engine body was cast and would be pleased to have an aluminium casting made from them without expense to you. I shall do whatever I can in helping you to get an accurate copy of the plane and the motor."

On December 17 1948 the original Wright machine was formally presented to the Smithsonian Institution by Milton Wright, of Dayton, Ohio, a nephew of Wilbur Wright. It bore the label:

THE ORIGINAL WRIGHT BROTHERS' AIRPLANE

The world's first power driven heavier-than-air machine in which man made free, controlled and sustained flight. Invented and built by Wilbur and Orville Wright, flown by them at Kitty Hawk, North Carolina, December 17 1903.

By original scientific research the Wright Brothers discovered the principles of human flight. As inventors, builders and flyers, they further developed the airplane, taught man to fly, and opened the era of aviation.

Wilbur and Orville Wright

Wilbur Wright was born on April 16 1867 near Newcastle, Indiana, and Orville Wright on August 19 1871 at Dayton, Ohio. They had two elder brothers, Reuchlin and Lorin, and a younger sister, Katharine.

From an early age Wilbur and Orville showed a mechanical and inventive aptitude which was fostered without stint by their father, Bishop Wright. He encouraged them to read widely, to follow useful hobbies, and particularly to satisfy their natural curiosity, wherever it might lead them, by investigating the whys and wherefors.

The family could trace its descent to a John Wright, who owned Kelvedon Hall, in Essex, in 1538. A descendent, Samuel Wright, migrated to America in 1836. Another ancestor was a van Cleve, who emigrated from Holland in the 17th century.

Curiously enough both Wilbur and Orville showed an aptitude for journalism, though in their years of fame both were reluctant to say anything more than necessary. In those early days they combined the mechanical and journalistic aptitudes by designing and constructing their own printing press.

In 1892 the brothers decided that the safety bicycle would become popular in America and they began in business to sell the better known makes then being manufactured. Within three years they were making their own bicycles—one named van Cleve after their Dutch ancestor, and another the Wright Special.

In 1896 the death of Lilienthal turned their attention to the possibilities of flight. The story of their activities from that date until their successful flight in December 1903 has been related in the earlier pages of this paper.

In 1906 and 1907 both brothers were under constant strain of negotiating with governments and others for the rights of their machines. In 1908 and 1909 there was the additional strain of giving flying demonstrations and instructing others in the art of flying. Orville's accident when demonstrating at Fort Myer in 1908, resulting in the fracture of his left leg and thigh, and breaking a number of ribs, affected his health for the rest of his life. Wilbur was never able to let up once business interests demanded so great a part of his energies. He died from typhoid fever on May 30 1912 at the early age of 45.

Orville Wright made his last trip to Europe in 1913, accompanied by his sister Katharine. By 1915 he had decided to sell his interests in The Wright Company and leave business worries to others. He turned to his first love, aeronautical research.

On January 31 1917 he wrote to Griffith Brewer:

> "The past ten days we have been working on the new wind tunnel. . . . The channel itself is three feet square, connected to a distributing chamber seven feet square by twelve feet in length. The laboratory room is 60 feet by 40 feet by 16 feet. The motor is to be of ten horsepower. . . . If there is any difficulty in getting a uniform current—that is a uniform velocity over the greater part of the channel—I think I can get it, as we did in our early experiments by screening the parts of the channel having greater velocity."

On July 13 1918 he wrote to Brewer:

> "I have lately put up a small tunnel in my laboratory in which we have a wind velocity of over 160 miles an hour. McCook Field (the Government aeronautical engineers experimental station) is now making an exact copy of it with the intention of later building it on a seven foot scale."

Much of Orville's time in the years which followed was taken up with replying to the many correspondents who asked his opinion of some particular invention of their own, or who asked for a fuller explanation of some point in the early gliding and flying experiments. He took particular care in answering these questions.

For most of his life he suffered from the after effects of his accident and was reluctant to take part in any public ceremonies in aviation, particularly when he was cast for the chief character.

Orville Wright died on January 30 1948.

One may perhaps end this brief additional biographical note with tributes from two members of the Society—Griffith Brewer and Sir Francis McClean. On the occasion of the death of Wilbur Wright, Brewer wrote in the JOURNAL of the Society:

> "The present generation will never completely realise the magnitude of the loss to aviation caused by the death of Wilbur Wright, and yet it requires but a moment's thought to recognise that his name will live until all histories are obliterated, for, with his brother Orville, he accomplished the dream of ages, which men of acknowledged science had become in the habit of first attempting to accomplish, and then alleging the feat to be amongst the unattainable. . . .
>
> "The simple life had great attractions for Wilbur Wright. A piece of stout canvas nailed between two pieces of 2 in. by 3 in. wood supported at their ends on the rafters of the shed containing the machine, formed the bed on which he slept, and often at five in the sparkling September mornings he was to be seen taking an early cold water wash while the water

for the coffee was on the boil. The machine was always his first care, for it was the only machine available and it served for all the flights of those last four eventful months of the year 1908.

"The same shed, which by the by was too small to take the machine until the rudder had been folded back, served as his office as well as his bedroom, and as may be well imagined, the popular interest in those early flights attracted a large and in some cases unwelcome correspondence. He had no secretary to look after his letters, and most of his time being taken up with the machine, flying, and answering questions, correspondence could only have very limited attention. . . .

"I found Wilbur Wright quite open about his work; there was no air of mystery or cloaking the achievement of flight with artificial embellishments. Just the simple story of two brothers who had always played together and worked together, and one whose health required constant out-door exercise."

On the death of Orville Wright, Sir Francis McClean wrote in the JOURNAL,

"I first met Wilbur Wright through the kindness of Griffith Brewer, in Paris in December 1908, and at Le Mans, in company with Roger Wallace, Professor Huntingdon and Eustace Short, he gave us flights—six minutes each and thirty feet above the ground.

"My first impressions of him were his unemotional face, his preciseness in speech and his entire lack of excitable action.

"I did not meet Orville till May 1909, when the two brothers came to England and were entertained by Hedges Butler and the Aero Club and visited Shellbeach at Leysdown which was the precursor of Eastchurch aerodrome.

"Orville had the same preciseness as Wilbur, but was more expressive both in face and speech and often seemed to be the predominant partner, especially when business was under discussion.

"But I soon found that my first impressions were superficial and that behind their precise manner, both of them were endeavouring to assist in every way they could those who required help. There were exceptions—few and envious ones.

"In a short stay at Dayton in 1911, I, with Dr. W. J. Lockyer, visited their home. Wilbur was not there, but Orville and Katharine and their father made us welcome with a kindliness that is beyond words. Katharine was a very real part of the Brothers Wright and whenever I think of the brothers the sister is with them in the picture. The family was indeed a wonderful example of peace and unity with a simplicity that ignored the greatness that was their just due.

"One human characteristic that they both lacked was showmanship. If they had been showmen they would have been world famous in 1903 and the wretched dispute with the Smithsonian would never have developed. If they had been showmen no one now could have found an opening for belittling them.

"But they were not showmen."

The Memorial Years, 1913 - 1953

"Each year I'll give myself, the better me,
Developing for you, For I intend
Since I am yours, my friend, to try to be
A better friend.

P. H. Lowry.

"When Wilbur Wright died on the 30th May 1912," wrote Griffith Brewer in his book *Fifty Years of Flying*, "his English friends discussed how best they could found a memorial to perpetuate the memory of the great work which he and his brother Orville had accomplished in inventing and flying the first aeroplane."

It was suggested by T. W. K. Clarke, a member of the Council of the Society, that an annual lecture which would identify itself with the objects of the Society, scientific investigation, research and application in aeronautics, should be founded. The raising of the necessary fund to endow the lecture was left to Griffith Brewer, and to him must be given the chief credit for inducing many friends and admirers of the achievements of the two brothers to help in founding the now famous lecture.

Over thirty years after the death of Wilbur Wright, Griffith Brewer was able proudly to write:

> "The reading of this lecture has become the greatest honour in aeronautical science and for many years the custom has been for the lecture to be delivered by an Englishman one year and by an American the following year."

Only once, indeed, has the lecture been read by any other national, by Professor L. Prandtl in 1927.

No aeronautical lecture in the world approaches the prestige of the Wilbur Wright Memorial Lecture. All are aware of a feeling of its importance, of the high honour with which the reading of it is held in both the United States and Great Britain; but its importance and the honour attached to reading it, have not been attained simply because it has been a lecture founded in the memory of a great aeronautical pioneer. This year is the 50th Anniversary of the first controlled flight made by an aeroplane in the long history of mankind and I believe it may rightly be said that a major part of aeronautical progress in fundamental research and in other directions of aeronautical endeavour in those years, has been due to the outstanding abilities and vision of those who have been chosen by the Council to deliver the Wilbur Wright Memorial Lecture.

The Wilbur Wright Memorial Lecture has, too, a fundamental importance in other ways. In 1920, J. C. Hunsaker, who later became the Chairman of the National Advisory Committee for Aeronautics in the United States, said in his Memorial Lecture:

> "In honouring Wilbur Wright we meet on common ground. Friendly relations between our countries will be furthered by trans-Atlantic flying, and it seems very appropriate that the most intimate contact should be maintained by those technical and scientific workers who are striving for the same end; the improvement and application to the gift of flight left us by Wilbur Wright."

Another great American, T. P. Wright, designer of many outstanding aircraft, one-time head of the Aircraft Branch of the United States Production Board in the Second World War and in 1944 Civil Aviation Administrator, a man of great vision, emphasised the point raised by Hunsaker.

> "How admirable was the decision of that early Council of the Royal Aeronautical Society," he said in his 1945 lecture, "to alternate between lectures from England and the United States. It gives a recurring occasion for those of us from the other side of the Atlantic privileged to have been selected to reaffirm our friendship for you; to exchange information; and to present our point of view on aeronautical subjects of timely interest."

Edward Warner, whose abilities are encyclopaedic in their aeronautical scope and whose nationality as President of I.C.A.O. is one of internationality, in his 1943 lecture said,

> "In this annual homage to the memory of Wilbur Wright you have provided a reminder of the swift and generous appreciation that the Wright Brothers' work always found in England. It reminds us, too, in a field that has too often been the subject of national self-glorification and in a time when chauvinism has been rife, that aeronautical science, like other sciences, knows no barriers of race or nation. The Wrights, like the noblest of their successors in Britain and elsewhere, sought knowledge for its own sake that it might benefit all mankind. We are well on our way to the time when we can again think of aeronautical science in terms of pure benefit and of new-found knowledge freely broadcast to the world."

Much information and many suggestions for future progress have been published in these annual lectures. In particular Orville Wright himself has provided to the Wilbur Wright lecturers first hand data and information of the early work of his brother and himself, and this paper includes many abstracts from the lectures, as well as tributes to the two pioneers.

The first Wilbur Wright Memorial Lecture was given by Horace Darwin, a member of that famous family which, by its devotion to, and clear thinking on many aspects of, science, has set a high example to those who have followed.

Of Wilbur Wright, Darwin said:

> "No Memorial Lecture is required to make us all admire the character of the man, his brilliant engineering work, the scientific method by which he obtained his results. Each step forward was secured by careful reasoning based on former trials; each step was tested separately, all available data were used. An account of the method and results of his original experiments has not yet been published, and would be of extreme interest. . . . A new chapter in the History of Engineering has been begun. The first page has been written by the man whose name we honour tonight as the pioneer of aviation. . . . He is gone, but his work will live for all time."

That outstanding aeronautical figure F. W. Lanchester, was in the Chair for the 1915 lecture read by another remarkable figure in the history of the early development of aviation, Professor Bryan. Bryan lectured on Stability in aviation, a subject title which might, nearly forty years later, be interpreted differently. The lecture was an exposition of work which Bryan had started in 1903 and to the necessity for which he had publicly drawn attention as far back as 1897. Bryan received the Gold Medal of the Society for his work which was of such major importance. It was fitting that Lanchester, who had done notable work on aeroplane stability on different lines to Bryan, and who had lectured as early as 1894 on his famous circulation theory, should be in the Chair, and should only a few years later also receive the Gold Medal of the Society. Bryan was the pure mathematician and Lanchester the practical engineer.

> "I had many opportunities of seeing Wilbur Wright," said Lanchester, introducing Bryan, "and talking with him at the time when he was demonstrating his machine in France in 1908, and then formed the opinion that the characteristic in which Wilbur Wright excelled was in skill in the art of flying. One has only to recall his performances in France to see how much superior he was to the other fliers at that time. When Farman was flying cautiously round in circles of large radius, Wilbur Wright, by virtue of his combined rudder and warping control, was able to turn and twist in the air in curves of very small radius, in brief, his flying was like that of a bird.
>
> "I always found Wilbur Wright commendably careful of the reputation of flying from the public standpoint; he had a great sense of his responsibility in this regard. There is no doubt that if he had wished he could have undertaken cross country flights with good prospect of success long before anything of the kind was attempted, but he possessed the moral courage not to risk the reputation of the new mode of locomotion for the sake of personal popularity."

The 1918 lecture was read by Dr. Durand, Chairman of the American Advisory Committee for Aeronautics, and the editor of the six volume work on *Aerodynamic Theory*, published 1929-35.

Durand's paper is of considerable interest in the light of present day knowledge. He suggested, for example, that there must be an optimum design in any given material and thought that a marked saving in weight could be obtained without loss of strength, and saw no reason why there should be any limit in aircraft size as long as the cube/square law could be kept in check.

"Broadly speaking," he said of another aspect of flight, "the ideal aeroplane should be able to change its wing area in accordance with the conditions and circumstances of flight."

He added cautiously that no devices proposed up to then had been altogether satisfactory, a statement which still remains true after forty years.

I believe the following paragraph is worth placing on record here from his lecture.

> "It is perfectly easy to build a safe moderate speed family carriage sort of machine which will be stable and secure, under almost any conditions likely to develop. Such machines would be scorned by fighting pilots, but when civil aeronautics begins to come into its own . . . and there comes a demand for safe machines for civil purposes, including family outings for the week-end from the city to the country or to the sea coast, then we may anticipate a larger recognition of the qualities making for safety and stability, and we shall find machines provided having such characteristics and in practically any desired degree."

A contrasting note came in the title of the 1919 lecture on the "Progress of Aviation in the War Period" by Leonard Bairstow. The lecturer himself had had

much to do with that progress. Of the Wright Brothers he said

> "Their early flight experiments were directed to the development of controls by means of which the senses of the pilot were introduced into the mechanics of the aeroplane motion. . . . The problems of inherent stability were at that time untouched in practice, although Bryan was then working out the mathematical theory which has now been adopted as the best statement and solution of the problem of the disturbed motion of an aeroplane."

The impression one gets of the value of any lecture depends upon many things besides a critical understanding of the lecture content. I take care to emphasise here that I am speaking personally, for I was very impressed by G. I. Taylor's lecture on "Scientific Methods in Aeronautics" for two reasons. One was the astonishing simplicity of Taylor's research methods and the other his real understanding of humour for successful delivery of a scientific lecture. Taylor on Golf might become a classic if this particular Taylor could be persuaded to write it.

The few notes in his lecture are illuminating.

> "Try to imagine a race of men who lived entirely for golf, who thought about it at meals, practised it by day, dreamed about it at night and talked about it always. I do not suggest that such a race ever existed, but to the philosopher no conception is too revolting to be used in the practice of his art. This race would no doubt develop a class of highly specialised technical experts who would invent balls and clubs of the most complicated character, devise special apparatus for exercising the muscles used in doing a drive, invent special headrests designed to fix one's eye on the ball, etc., etc. . . .
>
> "At the same time there might exist a few lunatics who were so made that they took not the slightest interest in golf. . . ."

I leave you to read the argument in the JOURNAL for September 1921 for it was to show that "investigations in which the scientist has in view, at any rate, some question relating to aeronautics . . . are not the kind of investigations which are likely to produce the greatest or the most profound changes in the science . . ."

A paragraph or so later in his lecture he added,

> "The difference between the methods by which a pure and applied scientist approaches his work is of some interest. If one compares the lives of distinguished applied scientists like Siemens, Marconi or Wilbur Wright with those of pure scientists like Kelvin or Lord Rayleigh, one will at once be struck by the colossal difference in the range of investigations attacked by the two types of men. The investigations of Lord Rayleigh extend over many branches of heat, light, sound, electricity, astronomy, aeronautics, molecular physics, mathematics and even physical research. The investigations of Siemens are practically confined to one branch of electricity, those of Marconi to another and those of Wilbur Wright to one branch of aeronautics. This is not due altogether to lack of breadth of vision on the part of applied scientists."

In 1916 Griffith Brewer gave his comprehensive lecture on the "Life and Work of Wilbur Wright," from which much has been quoted in this present paper. Six years afterwards, on June 15th 1922, Lt. Col. Alec Ogilvie, another close friend of the brothers, paid a moving tribute to Wilbur Wright in his Memorial Lecture. Ogilvie had been in charge of new aircraft designs during the latter part of the First World War.

> "When ten years ago a telegram came from Orville saying that Wilbur had died," said Ogilvie, "I felt as if I had lost an elder brother, who was not only a past master on the subject of flying, a master willing and anxious to impart anything he knew, but also one who would give careful, painstaking and entirely unselfish consideration to any matter, however unimportant. I never knew him to give a hasty or ill-considered judgment about anything or any person.
>
> "It was in December 1908, that I first met him, when he was at Le Mans, demonstrating to the European public at large, and to the French in particular, that the doubts and suspicions with which the statements of themselves and their friends had been received were without foundation and that real flying was an actual accomplished fact.
>
> "I had gone to France in order to learn as much as possible about the design and construction of an aeroplane before setting out to build one of my own, and after visiting the Salon and the works of all the notable constructors, went out to Le Mans to see the Wright machine.
>
> "There were a thousand or more people waiting at the aerodrome on the chance of seeing something, and after an hour or two before our eyes there actually happened what we had heard about but had only half believed. My diary reads as follows:—
>
> "'W. Wright made two wonderful flights in afternoon, all kinds of evolutions, turning, skimming close to the ground, gliding without engine from 200 feet. A true and complete flying machine. No chance of speaking to Wright.'
>
> "Returning a few days afterwards, I arrived to find Wright circling the aerodrome for the Michelin Cup. After a time he was brought down by some small defect in the oiling system.
>
> "A mere trifle had prevented him from making a two-hour flight which would have marked for him an important stage, and there was only one more day to go before the end of the year. Nevertheless, while packing the machine away into its rough shed, deciding upon and carrying out a cure for the lubrication trouble, he was quite calm and unhurried.
>
> "After everything was in order for the next day we had a long talk, walking about the frozen aerodrome and discussing his plans and mine. One could not help being impressed by his absolute honesty, sincerity and self-control, as well as by his obvious intellectual powers, and I conceived a very great admiration for his character.
>
> "It was impossible to evade the thought that he was a man apart, and so I always thought him, notwithstanding the growth of our personal relations into a very warm friendship.
>
> "The genial warmth of this I should like to illustrate by a little incident which happened at Eastchurch in 1911, when he was stopping in camp with me and helping to get my little racing machine ready for the Gordon Bennett.
>
> "We were running the engine in the shed with the doors closed, and Wilbur was testing the propeller revolutions by counter and stop watch. He was wearing a bowler hat, and when withdrawing his head and shoulders through the front spar bracing, managed to get the hat knocked off his head by a wire. It rolled across the plane and was caught by the propeller, flew round the shed, coming to rest in a corner. After this trip the hat was considerably dented, so we bought him a new one in exchange. The following reference from a letter shows the pleasant humour and kindly spirit which so endeared him to his friends:—
>
> "'P.S. When I came to settle accounts with Mr. Brewer I found several disputed accounts, in one of which he claimed you were the only person interested. I claim that if an old hat increases in value in proportion to the number of holes put into it that I have the right

to see if there is any possible chance of getting in one or two more before trading it off!' "

Speaking of the achievement of the two brothers, Ogilvie said,

"It has been generally accepted that the Wrights were experimenters who grasped the essentials of the problem of flying, as it was then known, and tackled them in a practical and intelligent way. Also that they were the real and true pioneers of mechanical flight in December 1903.

"There are still men, eminent and distinguished men, who believe that this success was really due to the superior flying skill and technique of the two brothers. They do not appreciate that it was a demonstration of something bigger and more important even than that—a demonstration of a firm structure of knowledge based on experimental work of the most solid kind.

"It is greatly to be deplored that it has not been possible to publish the results of the wind-channel work which was done in the workshop at Dayton after the 1901 gliding was over, because the actual figures of these experiments would have dispelled the last doubt. However, a study of the results attained affords an aeronautical engineer evidence which should be sufficient to convince him.

"Take the small racing machine which in 1910 the Wrights produced to compete in the Gordon Bennett Cup and compare it with their standard machine of that date, and it is obvious, even more so now than it was then, that both machines were designed on a scientific basis founded on definite data. The aspect ratio is about the same in both machines, *i.e.* about 6 to 1, and the gap chord ratio about unity, both of which features are still standard practice today. The bold increase in the surface loading from $2\frac{1}{4}$ to 6 lb. per square foot should be noted.

"I was in Dayton during the time the small machine was being designed and built, and saw how reference was continually being made to little pocket-books, in which were collated the results of the wind channel research work carried out mostly during the winter of 1901-1902.

"It was known that the French flyers would be sending over a strong team to capture the cup and that they would be using the new 70 h.p. Gnome, an engine of good power for weight, and one which was considered in those days to be a very formidable proposition and by many almost too powerful for a single-seater machine. This may be amusing to my present audience, but I would remind them of the excitement when the 50 h.p. Gnome was put into the Bleriot monoplane in place of the 25 Anzani.

"The Wrights made up their minds that they would double the speed of their standard machine in order to win. They were much behind time, and had to make the utmost use of their standard equipment. They therefore designed and built a machine of less than one-third the area, two-thirds of the weight and double the power of their standard machine.

"When first flown by Orville the machine came up to its designed performance—was in perfect balance and control.

"It is doubtful if any aeronautical designer of the present day, with all the increased knowledge at his disposal, could make so immediate a success of so radical a departure.

"It has been my fortune to have had a great deal of experience in the trials of new designs of aircraft and to have watched many through their teething troubles, but looking back on that performance of twelve years ago it is evident that a very full knowlede of design data was available to the Wrights at that date."

The title of Ogilvie's lecture was "Some Aspects of Aeronautical Research" and more than half of his paper was devoted to giving details of the research carried out by the brothers. He added to the history of their work.

"The first lesson to be learnt from the work of the Wright Brothers is of the immense importance of fundamental research in the laboratory. Another very important lesson to be drawn is as to the value of the closest co-operation between laboratory and field work. The first period was devoted to the study of all the available information and to thought about the essentials of the problem. Then came two periods of practical experiment in the field, the first short and the second of considerable length. This full-scale work gave the Wrights a good deal of experience and confidence in what they were doing, but above all it made it clear to them that whether they liked it or not they had to go back to the beginning and get down to the fundamental research, which was the only foundation on which a permanent structure could be built. . . . Brilliant craftsmen and engineers though they were, it is certain that the Wrights would never have solved the problem of flight if they had not the fundamental data to guide them in times of difficulty."

Dr. Joseph Ames, Professor of Physics at the Johns Hopkins University, and Chairman at the time of the Executive Committee of the National Advisory Committe of Aeronautics, also emphasised the points made by Ogilvie of the way the Wrights carried out fundamental experiments. In his 1923 lecture he said,

"It is a great honour to be invited to give the Wilbur Wright Lecture on Aeronautics, especially so for a fellow citizen of the Wright Brothers. . . . The fact cannot be emphasised too often that, from the very beginning of their work, their point of view was that of the scientific investigator. Empirical methods, engineering development, did not satisfy them; they wished to know the underlying scientific facts, and to build on them. They had in reality, the true concept of the purpose of the great aerodynamic laboratories of today."

Lt. Col. Ogilvie took the Chair at the 1924 Lecture when Lt. Col. H. T. Tizard read his paper on "Fuel Economy in Flight."

"Since 1912 the position of the Wrights has greatly altered," said Tizard, "and they are everywhere acknowledged to be the real originators of the flying machine. As to this I cannot do better than quote Sir Walter Raleigh in his book 'The War in the Air':—'New inventions are commonly the work of many minds, and it would be easy to name at least half a dozen men to whose work the Wrights were indebted. But these were tributaries; the main achievement belongs wholly to the Wrights. Their great perseverance through long years, in the face of every kind of difficulty, is only part of their distinction; the alertness and humility of mind which refused all traffic with fixed ideas, and made dangers and disappointments the material of education, is what stamps greatness.'"

The 1926 Lecture was on "Sustentation in Flight" by F. W. Lanchester, who received on the occasion the Gold Medal of the Society, an award long overdue.

It was due to the early work of Dr. Prandtl, who read the next lecture on May 16 1927, that Lanchester's own work was recognised. Prandtl also received the rare honour of the Gold Medal. Dr. Prandtl is the only lecturer to read the Wilbur Wright Memorial Lecture who was not American or British.

In 1928, F. Handley Page read his notable paper on "Slots in Aircraft Wings." From his early days in aviation he had had a keen appreciation of what the Wrights had done. After referring to the gliding experiments of Lilienthal he added,

"Then came the great contribution of the Wrights, who discarded Lilienthal's acrobatic control and, carrying through the whole modern programme of wind tunnel research, detail design and construction, found out by practical flying that essential feature of control which has been used in practically every aeroplane that has been flown."

At the Annual Dinner of the Council following the 1928 Lecture the Council paid a special tribute to the work of Orville Wright and presented him with an illuminated address signed by all members of Council and their guests.

The 1929 Wilbur Wright Memorial Lecture was remarkable in a number of ways. It was read on the twentieth anniversary of the first flight across the English Channel by Louis Bleriot, on July 25th 1909. The lecturer was the Hon. William P. MacCracken, Assistant Secretary of Commerce for Aeronautics and a member of the National Committee for Aeronautics of the United States of America. The title of the lecture was "Science in Relation to Regulating and Promoting Civil Aviation," and the venue of its delivery the Science Museum at South Kensington. For the occasion the original Bleriot monoplane had been lent to the Museum.

"At the reading of the lecture tonight," said the Master of Sempill, the President, "There has gathered together one of the most distinguished audiences which has listened to the lecture. He would like to remind that audience that they had gathered together on hallowed ground. Above their heads were two of the most historic aeroplanes in the world, namely, the original Wright biplane on which the first flight on a power-driven heavier-than-air craft had been made in December 1903, and the original Bleriot monoplane in which M. Bleriot had flown the Channel for the first time that day tewnty years ago. Around them, too, were many other historic machines and relics of the efforts which man had made to fly."

Among the distinguished audience present on that unique occasion was Major Lester Gardner, an Associate Fellow of the Society, who was one of the moving spirits in the founding of the Institute of the Aeronautical Sciences, of which he became secretary. In an astonishingly short time by his atomic energy he raised the Institute to a position of power among the aeronautical societies of the world. He was honoured with the distinction of Honorary Fellowship of the Society in 1939.

The Lecturer finished his lecture with the words,

"The field is international. The truth of this statement is well demonstrated by this occasion. This meeting is held in England under the auspices of the Royal Aeronautical Society. The lecture is dedicated to the memory of an American, Wilbur Wright, who, with his brother Orville Wright, first demonstrated the practicability of man navigating the air in a power-driven heavier-than-air machine. The date selected is the twentieth anniversary of the first great international flight, made by Louis Bleriot, a Frenchman, from Calais to Dover. As an illustration of the youthfulness of this art, it can be pointed out that both Orville Wright and Louis Bleriot are still actively engaged in applying their efforts and genius to the advancement of the science in which they were pioneers. Thus it is certainly apparent that the promotion and regulation of civil aviation presents one of the most fascinating scientific as well as economic and administrative problems of our age."

With but few exceptions the Wilbur Wright Lecture has been preceded or followed by a Council Dinner at which many distinguished guests are invited to honour the lecturer. In 1932 the Lecture was given in the Science Museum by H. E. Wimperis, the first Director of Scientific Research at the Air Ministry and later a President of the Society. One of the distinguished guests was that very remarkable lady, Amelia Earheart, who had just flown the Atlantic. Not since the first one or two lectures had a lady been present at a Council Dinner.

Wilbur Wright Lecturers seem to have a knack of saying the right thing some years before it becomes devastatingly true. Mr. Wimperis was no exception. Lecturing on "Some New Methods of Research in Aeronautics," he was a little pessimistic about the future, in certain respects.

"Are we simplifying? I am not sure we are, and my doubt increases when I think of the growth of the complexity in our control surfaces. . . . But who shall control the controls? As our grandfathers would have said '*Quis custodiet ipsos custodes?*' and to that question I do not recollect that they made any answer. And if I am asked 'To what great end is all this activity directed?' what is to be my reply? Can I truthfully say that it is imperatively bound to add to human happiness? I fear not. . . . The world gathers knowledge faster than wisdom. . . . The benefits to be enjoyed from any new discovery, that of human flight for instance, turn, I suggest, less upon its mechanical perfection, however splendidly satisfying to the engineer, than upon the dreams and ideals of those who are able to guide its destiny and guard its use. 'Where there is no vision the people perish.'"

Nearly a quarter of a century after these words were spoken they have become of a significance which cannot be over-rated. To many, however, the dreams are nightmares and the ideals those of the untutored savage.

Three years later, on the occasion of the lecture by D. W. Douglas in 1935 on "The Development and Reliability of the Modern Multi-engine Air Liner," Lt. Col. J. T. C. Moore-Brabazon, President of the Society, emphasised what Mr. Wimperis had said.

"It was indeed the wish not only of us in this country, but the wish of the whole world, that we should be worthy of what the Wrights did and not to reduce the whole thing to nothing else than armaments."

As I read through this outstanding series of lectures, I am certain that in them lies the very heart of technical aviation progress, and high purpose for such progress. In 1937, when H. E. Wimperis was President, the great Theodore von Kármán lectured on "Turbulence" and finished his lecture with the words,

"Many engineers today consider the problem of turbulence merely as an interesting chapter of mathematical physics. They may be right. However, they should remember that if we meet a practical question in aerodynamics design which we are unable to answer, the reason that we are unable to give a definite answer is almost certainly that it involves turbulence. Hence, I believe that in spite of the complex mathematical and physical aspect of the problem of turbulence, the scientist is justified in saying to the practical engineer: *Tua res agitur* (your case is on trial). It was the principal aim of my lecture to show this."

von Kármán defies analysis, as do most men who carry out fundamental investigations or research. One must just joyously accept them. The literature relating

to turbulence is full of von Kármán's contributions and, to quote Professor Southwell,

> "would have been fuller if it were not for his idiosyncrasy which caused him to have his brightest ideas sitting in Continental beer cellars. Having no paper handy he made his calculations on the pseudo-marble top of the beer table; in would come a friend whose conversation started a new idea, and with that new idea they would turn to fresh beer cellars and virgin tables; and later on a third professor, less original and less scrupulous, would come into the first cellar and find the unfinished calculations; these he would then finish off and publish as his own work."

More power to von Kármán's elbow!

von Kármán's lecture was followed by one on "Materials of Aircraft Construction" by Dr. H. J. Gough. This was the first time that the lecture had been devoted to what, after all, is a necessary part of flight in this world. It was remarkable in the breadth of its survey and the thoroughness of its presentation.

Wilbur Wright lecturers are men of infinite pains.

> "I spent an interesting afternoon with Dr. Gough," wrote Griffith Brewer to Orville Wright on March 2 1938, "at the Science Museum, trying, with the help of Davy and the draughtsman who drew the engine on the original machine, to give him particulars as to the materials used in the making of the engine and of the machine itself. These particulars are wanted for comparison with the materials available today in aircraft construction."

Dr. Gough said, in his lecture, when referring to the 1903 engine materials,

> "Mr. Griffith Brewer has been good enough to take considerable interest in this matter and has obtained from Mr. Orville Wright his recollections regarding the materials used. As a result, it is now certain that the piston and cylinders were of fine-grained grey iron of a high quality as used at that time for high pressure steam valves, etc.—tests made by the Wrights showed this iron to have a tensile strength of 39,000/in.^{2}; also, the crankshaft was of high carbon (tool) steel, not heat treated after being cut from a slab. Some information of a more general nature regarding a few other components has also been revealed by Mr. Wright; the cylinder liner and piston were of cast iron; the crankcase and cylinder block were of aluminium alloy; the connecting rod was of seamless steel tubing screwed into phosphor bronze big-ends; the bearings—crankshaft, propeller and camshaft—were of babbitt metal; the valves had steel stems and cast iron heads; the chains driving the propellers were No. 155 diamond roller chains.
>
> "The engine was constructed by the Wrights; it developed approximately 12 h.p., weighed about 180 lb. and consisted of 4 cylinders in line, water-cooled, of 4 in. bore and stroke. The constructors developed no new materials for this engine and the materials used represented general engineering practice of that period. The information supplied by Mr. Orville Wright, together with the results of a careful search of the relevant technical literature and other publications of the time has enabled an estimate to be formed of the principal materials which were probably used in the 1903 engine. . . .*
>
> "Turning to the structure of the Wright machine . . . the materials used were wood, cloth and wire for bracing purposes. The woods were silver spruce, grown in the eastern states of the U.S.A., also, second growth ash; the tensile and compressive strength of the spruce, in the direction of the grain, can be reasonably assessed at about 8 and 2¼ tons/in.^{2} respectively. The two propellers—which gave a thrust efficiency of 66 per cent.—were also spruce; they were of the 'built-up' type construction. The fabric was 'Pride of the West,' muslin as sold over the counter in 1903; it was not doped. A specially interesting point about the use of this cloth—which, in fact, constituted one of the claims of the Wright patent—was that it was cut on the bias, having the threads situated diagonally to the lateral spars and the longitudinal ribs with which it formed truss systems. By this combination and arrangement 'we secure a surface of very great strength to withstand lateral and longitudinal strains, but capable of some twisting movement.' No record can be traced of the strength of this cloth and surmise is not profitable. The bracing wires, of circular cross-section, consisted of ordinary piano wire and, as such, would be of plain carbon steel, probably having 0·6 per cent-0·8 per cent. C. content and a tensile strength of something between 80 and 120 tons per sq. in.†
>
> "Such were the materials carefully selected by the Wrights for the best possible combination of lightness and mechanical strength. . . . In producing this famous biplane, and achieving their historic flight, they started a quest for ever lighter and stronger materials with such far-reaching results that have made possible not only the aircraft of today and tomorrow, but have also proved of inestimable value to every other branch of engineering construction and technical development. The impetus given to the science and art of the materials of construction probably owes more to the successful flight so modestly, but confidently, made in December 1903, than to any other single influence; the names of Wilbur and Orville Wright will always be honoured in much wider circles than those of aeronautical engineering."

The last lecture in the series before the outbreak of the Second World War was given by Dr. Lewis on "Modern Methods of Research" and is referred to at considerable length on page 757. It was followed by that given by Dr. H. Roxbee Cox on "Looking Forward. Prolegomena for a Detailed Study of the Future of British Civil Aviation." His detailed Initial Programme of Civil Design, Research and Development will bear careful examination and consideration to this day.

No lecture in all the long series was delivered in more dramatic and deeply moving circumstances; no Wilbur Wright Memorial Lecture came so near to not being delivered at all.

On May 22 1940 Griffith Brewer wrote to Orville Wright:

† These bracing wires were of fixed length. There were no turnbuckles or other end fastening to tighten them. Each wire was looped at the ends and slipped on to an oval-shaped fastening which had a double hook. Each wire was cut to the correct length and was at once replaced if it became slack.

* In a letter dated June 20, 1944, to R. Dexter, Secretary of the Institute of the Aeronautical Sciences, Orville Wright wrote: "I find from our records that the gasoline tank on the Kitty Hawk plane held four tenths (0·4) of a gallon. The motor consumed gas at the rate of 1½ gallons per hour, or 1 gallon in 45 minutes."
Lt.-Col. Ogilvie reminded the author of this paper that the engine was not fitted with a switch but was stopped by an exhaust valve lifter which afforded a very convenient method of restarting the engine in the air. Another interesting point was that there was no carburettor. Petrol was delivered direct into the inlet pipe by a small gear pump.

"You will know by my letter to you from the 'Samaria' that I had landed in England and curiously enough my return here was accurately timed so as to be safely home before the German push. I got home on Thursday night, the 9th, and the push began at two o'clock the following morning. Now, twelve days later, the Germans have taken Holland and most of Belgium, as you will have known long before you get this letter, and have driven their wedge through to the coast separating the British Army from the French. I will not attempt to forecast what this means, but my cure having been completed by the voyage home, I feel now that it is fortunate I did not delay my return, because it would have worried me far more to be in America wondering what was taking place at home than to be on the spot where the best and worst is known almost as soon as it takes place.

"The Wilbur Wright Memorial Lecture will be delivered on the 30th. I have not heard of any change in the arrangements."

Less than a week later, on May 28 1940, Brewer again wrote to Orville in a very different state of mind. The atmosphere in which he wrote this second letter may be briefly summarised by the following extract from *Their Finest Hour*, Volume II of Winston Churchill's History of the Second World War.

"On the suggestion of Mr. H. C. Riggs, of the Ministry of Shipping, the various boatyards, from Teddington to Brightlingsea, were searched by Admiralty officers, and yielded upwards of forty serviceable motor boats or launches, which were assembled at Sheerness on the following day. At the same time lifeboats from liners in the London docks, tugs from the Thames, yachts, fishing craft, lighters, barges and pleasure boats —anything that could be of use along the beaches were called into service. By the night of the 27th a great tide of small vessels began to flow toward the sea, first to our Channel ports, and thence to the beaches of Dunkirk and the beloved Army."

The evacuation of Dunkirk began that day, slowly, and ended on June 4, when the Prime Minister finished a speech to the House of Commons with the words:

"We shall go on to the end. We shall fight in France, we shall fight in the seas and the oceans, we shall fight with growing confidence and growing strength in the air; we shall defend our Island, whatever the cost may be. We shall fight on the beaches, we shall fight on the landing grounds, we shall fight in the fields and in the streets, we shall fight in the hills; we shall never surrender."

It was in this tense, this terrible situation, this situation of tremendous courage, on May 30, when over 50,000 men that day alone were evacuated from Dunkirk, that Dr. Roxbee Cox, one of the youngest lecturers in the series, was called upon to deliver the 28th Wilbur Wright Memorial Lecture in a blacked-out London.

But not without considerable argument.

On the day before Brewer wrote his second letter to Orville Wright he had learnt that the Secretary of the Society had received a request that the lecture should be postponed in view of the critical situation.

"Pritchard immediately telephoned members of the Council, and he decided in view of their acquiescence to postpone the lecture.

"I at once protested that this was a panic decision. . . . I contended that the paper was already published in advance form and that no Wilbur Wright Lecture had ever been postponed. Pritchard replied that it had once been postponed until September and I corrected this by saying that it had once been read in September to suit the convenience of an American lecturer, but it had not been postponed from the usual May date. Pritchard was not to be moved from his position, but agreed to my speaking . . . to members of the Council."

I well remember that day. Both of us were a little stubborn in our points of view about most things, but both were prepared to let the other have a go to express himself. Brewer succeeded in persuading some of the Council over the telephone that he was right, though I was still left having to give the final word because of the severe shortage of time.

"During my heated discussion with Pritchard," continued Brewer in his letter, "he said that as the President was away on the high seas, he would take instructions from the two Vice-Presidents, as provided in the Rules, so I took the responsibility and will justify my decision that the lecture is to be read before the next meeting of the Council of the Society. Both Pritchard and I calmed down after this decision. Unless therefore London gets bombed before Thursday the 30th the 28th Wilbur Wright Memorial Lecture will be held according to plan."

The two Vice-Presidents were Griffith Brewer and Air Vice-Marshal R. M. Hill, who agreed with Brewer.

Strong outside pressure was brought to prevent the lecture being read, even then, on the quite natural ground that every man was wanted at his job, instead of attending a lecture.

On May 31 Brewer again wrote to Orville Wright.

"According to plan Dr. Roxbee Cox read the 28th Wilbur Wright Memorial Lecture yseterday. . . . At the last moment Cox, who had been refused permission by his immediate superior, appealed to a still higher authority, Sir Wilfred Freeman, who saw no reason why the lecture should not be held. The holding of the lecture in the face of so much opposition was most satisfactory, and we most of us feel that should it be necessary to hold the lecture underground next year, the lecture would be held in this way."

The lecture the following year was by Juan Trippe, who flew over specially from America to deliver it in person, and the Chair was taken by Griffith Brewer who had been elected President of the Society.

To return to the 1940 lecture, Lt.-Col. J. T. C. Moore-Brabazon, who was in the Chair, said:

"There were present that evening several who knew Wilbur Wright well, and he was happy to include himself as one of them. They looked upon Wilbur Wright then, as they did now, as a superman, for he was a superman; but from the personal side he was extremely interesting. He had great simplicity of character. He was a man of few words*. He was a man who took some time to know, but when one was accepted by him, one could not help loving him, and he always remained a friend to be treasured and honoured.

"Wilbur Wright was a great character. The Brothers Wright always had a soft spot in their hearts for the Royal Aeronautical Society, and that was due to the fact that they were introduced to England and to the

* Not always. In discussions with Orville he spoke volubly and soundly and neither he nor Orville showed any of the diffidence for speaking they appeared to have in public.

ranks of the Royal Aeronautical Society in this country by Mr. Griffith Brewer*, who was their guardian angel here and also their friend. They always deemed themselves fortunate that they were introduced to Europe under his advice and under his cloak. It was only right at a time like this to stress the idealism of these two men and of the early workers in aviation. These lectures took place during the last war, and it was their determination to continue them during the present war, even if it became necessary to hold them, like the early Christians, underground in catacombs. In aeronautics, to deliver a Wilbur Wright Lecture was to become immortal."

Only two years later Moore-Brabazon himself had become an aeronautical immortal, and the Rt. Hon. Lord Brabazon of Tara, when he read the 30th Lecture in the series, "Ad Astra."

He paid a further tribute to the Wrights, and added:

"They were Americans to the tips of their fingers. I think outside their country they found here such sympathy and admiration as nowhere else, and the fact that their first machine is normally in our Science Museum testifies to the friendliness in their hearts. . . . The partnership between the two brothers was amusingly and graphically demonstrated at a dinner in Paris where Mr. Michelin, after a suitable speech, presented Wilbur Wright with the prize that they had earned of 20,000 francs. Wilbur expressed his thanks, carefully divided the notes into two packets, and without a word handed over one packet to his brother, while he put the other in his own pocket."

It must not be thought for one moment that the Wrights over all the years since their first flight had not found sympathy and admiration from their own countrymen. Far from it, but controversial issues had been raised in the United States which made it easier for friends in England to express themselves than had been the case always in America.

Attention has already been given to the lecture given by Dr. Warner in 1943 on "Post-War Transport Aircraft." It was not only a lecture which dipped so successfully into the future, farther than most eyes could then see, a lecture pressed to full and over-flowing in the refreshing draughts of its contents, but one which, in sheer length alone, would take any normal speaker three hours to read. Dr. Warner, speaking slightly slower than the speed of sound, accomplished the task, word for word, in the allotted time of one hour.

It has been the invariable custom on the occasion of the delivery of the Wilbur Wright Lecture, to exchange telegrams between the President of the Society and Orville Wright. Dr. Warner's lecture was one of the rare occasions when Orville expressed a strong opinion.

"On the occasion of the Thirty-First Wilbur Wright Memorial Lecture," he cabled, "I send the officers and members of the Royal Aeronautical Society my cordial greetings. Were Wilbur here today he would be shocked at the havoc the aeroplane has wrought, but I believe with slight variation the old saying still holds good, 'That he that liveth by the sword shall die by the sword,' and that we may now look forward with confidence to the post-war era of which my good friend Dr. Warner will speak."

The next lecture, of the same comprehensive character, though somewhat slower in its delivery, was given by the man to whom British aviation owes more than it can ever repay, Sir A. H. Roy Fedden, who lectured on "Aircraft Power Plant—Past and Future." It was Fedden who had warned the Government in the middle thirties of the disaster ahead for this country, as had T. P. Wright, in another way, for America. Complete victory was measurably in sight when Sir Roy gave his lecture, for 1944 saw the invasion of Normandy and the rapid advance from island to island in the Pacific against the Japanese.

This lecture was the first to show signs of suffering from the hebetude of secrecy, and it is an arguable point whether all technical lectures worthwhile giving can be worthwhile as long as so ill-named a thing as Security continues to raise its secret head. Perhaps I am pessimistic, but I do not believe I am.

Reference has been made on an earlier page to the 1945 lecture by T. P. Wright. A further brief quotation may be permitted from a man who is a great friend of the world.

"My conclusions are ones of optimism. I believe the Neanderthal man is growing up; that the spiral of progress will, by virtue of the airplane, be benevolent, that air transportation and air power will be largely beneficial to the human family. This need not necessarily be so, nor will it come automatically, but that it will occur, because of the work and efforts of men of goodwill now predominating in the world, I have no doubt. The scientific method of analysis, fact to principle, must be applied in appraising science itself and its effect on civilization."

E. F. Relf in the first post-war lecture, "Recent Aerodynamic Developments," also ended on an optimistic note.

"I do not believe there was ever a period in aeronautical history so bright with the possibility of future progress."

How rightly he put in a plea for ever-increasing facilities for research, and ended his lecture with the highly significant passage:

"Lastly, one other thing that I hope most fervently is that we may be able in the future to advance hand-in-hand with our great war-time ally and friend, the United States of America. Surely the continuance of the close co-operation which was so effectively established during the war years into the years of peace, would be the greatest tribute we could pay to those two great men who did so much to inaugurate the aerial age, and in whose honour we hold this Wilbur Wright lecture every year."

I feel I could not have ended this brief and in so many ways inadequate note about the Wilbur Wright Memorial Lectures in a finer way.

* The Wrights were in regular touch with members of the Society by correspondence, and met many in America, several years before they met Griffith Brewer.

The Wilbur Wright Memorial Lectures

1913	Horace Darwin, F.R.S.	Scientific Instruments, their Design and Use in Aeronautics
1914	Dr. R. T. Glazebrook, C.B., F.R.S. *Fellow*	The Development of the Aeroplane
1915	Professor G. H. Bryan, F.R.S.	The Rigid Dynamics of Circling Flight
1916	Griffith Brewer, *Associate Fellow*	The Life and Work of Wilbur Wright
1917	Lt.-Colonel M. O'Gorman, C.B.	Looking Ahead
1918	Dr. W. F. Durand (U.S.A.)	Some Outstanding Problems in Aeronautics
1919	Professor L. Bairstow, C.B.E., F.R.S., *Fellow*	Progress of Aviation in the War Period
1920	Commander J. C. Hunsaker (U.S.A.)	Naval Architecture in Aeronautics
1921	G. I. Taylor, F.R.S.	Scientific Methods in Aeronautics
1922	Lt.-Colonel A. Ogilvie, C.B.E., *Fellow*	Some Aspects of Aeronautical Research
1923	Dr. Joseph Ames (U.S.A.)	Relation between Aeronautic Research and Aircraft Design
1924	Lt.-Colonel H. T. Tizard, A.F.C., *Fellow*	Fuel Economy in Flight
1925	Rear-Admiral D. W. Taylor (U.S.A.)	Some Aspects of the Comparison of Model and Full-Scale Tests
1926	Dr. F. W. Lanchester	Sustentation in Flight
1927	Professor L. Prandtl (Germany)	The Generation of Vortices in Fluids of Small Viscosity
1928	F. Handley Page, C.B.E., Fellow	Slots
1929	The Hon. W. P. MacCracken (U.S.A.)	Science in relation to Regulating and Promoting Civil Aviation
1930	H. R. Ricardo, F.R.S., *Fellow*	The Development and Progress of the Aero Engine
1931	Glenn L. Martin, *Fellow* (U.S.A.)	The Development of Aircraft Manufacture
1932	H. E. Wimperis, C.B.E., *Fellow*	New Methods of Research in Aeronautics
1933	Colonel F. P. Lahm (U.S.A.)	Training the Airplane Pilot
1934	Professor B. Melvill Jones, A.F.C., *Fellow*	Stalling
1935	D. W. Douglas (U.S.A.)	The Developments and Reliability of the Modern Multi-Engine Air Liner
1936	D. R. Pye, *Fellow*	Surface Films and Lubrication
1937	Prof. Th. von Karman (U.S.A.)	Turbulnce
1938	Dr. H. J. Gough, M.B.E., F.R.S.	Materials of Aircraft Construction
1939	Dr. G. W. Lewis (U.S.A.)	Some Modern Methods of Research in The Problem of Flight
1940	Dr. H. Roxbee Cox, *Fellow*	Looking Forward. Prolegomena for a Detailed Study of the Future of British Civil Aviation
1941	Juan T. Trippe (U.S.A.)	Ocean Air Transport
1942	Lord Brabazon of Tara, M.C., P.C., *Fellow*	Ad Astra
1943	Dr. Edward P. Warner, *Fellow* (U.S.A.)	Post-War Transport Aircraft
1944	Sir A. H. Roy Fedden, M.B.E., *Fellow*	Aircraft Power Plant—Past and Future
1945	T. P. Wright, *Hon. Fellow* (U.S.A.)	Aviation's Place in Civilisation
1946	E. F. Relf, C.B.E., F.R.S., *Fellow*	Recent Aerodynamic Developments
1947	J. K. Northrop (U.S.A.)	The Development of All Wing Aircraft
1948	Arthur Gouge, *Fellow*	Size in Transport
1949	Dr. Hugh Dryden, *Fellow* (U.S.A.)	The Aeronautical Research Scene—Goals, Methods and Accomplishments
1950	Sir Richard Fairey, M.B.E., *Hon. Fellow*	Some Aspects of Expenditure on Aviation
1951	A. E. Raymond (U.S.A.)	The Well-Tempered Aircraft
1952	Sir Harry M. Garner, K.B.E., C.B., *Fellow*	Prophecy and Achievement in Aeronautics
1953	Professor N. J. Hoff, *Fellow* (U.S.A.)	Buckling and Stability

REFERENCES

1. *The Annual Reports of the Society*, 1867-1891, London.
2. *Progress in Flying Machines*. O. Chanute, New York, 1894.
3. Correspondence between the Wright Brothers and members of the Society (in possession of the Society).
4. Correspondence between Octave Chanute and members of the Society (in possession of the Society).
5. *Gliding*. Percy S. Pilcher. Aeronautical Classics. Aeronautical Society of Great Britain, London, 1910.
6. Angle of Incidence. Wilbur Wright. *Journal Aeronautical Society*, July 1901.
7. Experiments and observations in soaring flight. Wilbur Wright. *Journal of the Western Society of Engineers*, December 1901 and August 1903.
8. Aeronautical Progress. Presidential address to the Aeronautical Society on December 4 1902, by Major B. F. S. Baden-Powell. *Journal Aeronautical Society*, January 1903.
9. Aerial Navigation. O. Chanute. Address to the American Association for the Advancement of Science. *Journal Aeronautical Society* July 1904.
10. *The Aeronautical News*. Vol. I, No. 1, May 1906, New York.
11. The Wright-Brewer correspondence 1908-1947 (in possession of the Society).
12. The Wilbur Wright Memorial Lectures, 1913-1953.
13. The Life and Work of Wilbur Wright. Griffith Brewer. (The 4th Wilbur Wright Memorial Lecture.) *Journal Aeronautical Society*, July/September 1916.
14. The Langley Machine and the Hammondsport Trials. G. Brewer. *Journal Royal Aeronautical Society*, December 1921.
15. *Nature*, November 3 1921; January 26 1922; March 9 1922.
16. The Work of S. P. Langley. L. Bairstow. *Journal Royal Aeronautical Society*, November 1922.
17. The First Man-carrying aeroplane capable of sustained free flight: Langley's success as a pioneer in aviation. A. F. Zahm, Ph.D. Smithsonian Publication 2329. Washington, 1915.
18. *Aero and Hydro*. June 6 1914.
19. How we made our first flight. Orville Wright. *Flying*. The Aero Club of America Bulletin, December 1913.
20. The relations between the Smithsonian Institution and the Wright Brothers by Charles G. Abbot. Smithsonian Publication No. 2977, Washington, September 29 1928.
21. *The Wright Brothers*. Fred. C. Kelly, New York, 1943.
22. *Miracle at Kitty Hawk*. Fred. C. Kelly, New York, 1951.
23. The Wright Brothers as Aeronautical Engineers. M. P. Baker. Paper presented at the National Aeronautical Meeting of the Society of Automotive Engineers, April 17/20, 1950. Smithsonian Publication 4030, Washington, 1950.
24. The Wright Brothers, Wilbur, 1867-1912; Orville 1871-1948. *Journal Royal Aeronautical Society*, March 1948.
25. *U.S. Airservices* Magazine. March 1928.
26. *Aeronautica* 1949-1950. Institute of the Aeronautical Sciences, New York.
27. The 1914 Tests of the Langley "Aerodrome." C. G. Abbot. City of Washington, Smithsonian Institution, October 1942.
28. British Patent No. 6732, May 12, 1904. Improvements in Aeronautical Machines. Orville and Wilbur Wright. London, 1904.
29. *Fifty Years of Flying*. Griffith Brewer. London, 1946.
30. Affidavits in the United States District Court for the Western District of New York, of Robert L. Reed; Dr. Albert F. Zahm, 1914.
31. Report of Hearing before Sub-Committee No. 8 Committee on Military Affairs, House of Representatives. Statements of Hon. G. FitzGerald and C. G. Abbot, Secretary Smithsonian Institution, April 27, 1928. United States Government Printing Office, Washington, 1928.
32. *The Papers of Wilbur and Orville Wright*. Marvin W. McFarland, Editor. 2 Vols. McGraw-Hill, New York, December 1953.

The Year of Recantation 1942

"A dream lies dead here. May you softly go
Before this place and turn away your eyes."
Dorothy Parker.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 103, NUMBER 8

THE 1914 TESTS OF THE LANGLEY "AERODROME"

BY
C. G. ABBOT
Secretary, Smithsonian Institution

(PUBLICATION 3699)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
OCTOBER 24, 1942

Facsimile pages of the 1914 Tests of the Langley "Aerodrome" (The Abbot report) are reproduced on the next few pages.

THE 1914 TESTS OF THE LANGLEY "AERODROME" [1]

By C. G. ABBOT

Secretary, Smithsonian Institution

NOTE—This paper has been submitted to Dr. Orville Wright, and under date of October 8, 1942, he states that the paper as now prepared will be acceptable to him if given adequate publication.

It is everywhere acknowledged that the Wright brothers were the first to make sustained flights in a heavier-than-air machine at Kitty Hawk, North Carolina, on December 17, 1903.

Mainly because of acts and statements of former officers of the Smithsonian Institution, arising from tests made with the reconditioned Langley plane of 1903 at Hammondsport, New York, in 1914, Dr. Orville Wright feels that the Institution adoped an unfair and injurious attitude. He therefore sent the original Wright Kitty Hawk plane to England in 1928. The nature of the acts and statements referred to are as follows:

In March 1914, Secretary Walcott contracted with Glenn H. Curtiss to attempt a flight with the Langley machine. This action seems ill considered and open to criticism. For in January 1914, the United States Court of Appeals, Second Circuit, had handed down a decision recognizing the Wrights as "pioneers in the practical art of flying with heavier-than-air machines" and pronouncing Glenn H. Curtiss an infringer of their patent. Hence, in view of probable further litigation, the Wrights stood to lose in fame and revenue and Curtiss stood to gain pecuniarily, should the experiments at Hammondsport indicate that Langley's plane was capable of sustained flight in 1903, previous to the successful flights made December 17, 1903, by the Wrights at Kitty Hawk, N. C.

The machine was shipped to Curtiss at Hammondsport, N. Y. in April. Dr. Zahm, the Recorder of the Langley Aerodynamical Laboratory and expert witness for Curtiss in the patent litigation, was at Hammondsport as official representative of the Smithsonian Institution during the time the machine was being reconstructed and tested. In the reconstruction the machine was changed from what it was in 1903 in a number of particulars as given in Dr. Wright's

[1] For an account of early Langley and Wright aeronautical investigations, see Smithsonian Report for 1900 and The Century Magazine of September 1908.

list of differences which appears later in this paper. On the 28th of May and the 2d of June, 1914, attempts to fly were made. After acquiring speed by running on hydroplane floats on the surface of Lake Keuka the machine lifted into the air several different times. The longest time off the water with the Langley motor was approximately five seconds. Dr. Zahm stated that "it was apparent that owing to the great weight which had been given to the structure by adding the floats it was necessary to increase the propeller thrust". So no further attempts were made to fly with the Langley 52 HP engine.

It is to be regretted that the Institution published statements repeatedly [2] to the effect that these experiments of 1914 demonstrated that Langley's plane of 1903 without essential modification was the first heavier-than-air machine capable of maintaining sustained human flight.

As first exhibited in the United States National Museum, January 15, 1918, the restored Langley plane of 1903 bore the following label:

THE ORIGINAL, FULL-SIZE
LANGLEY FLYING MACHINE, 1903

For this simple label others were later substituted containing the claim that Langley's machine "was the first man-carrying aeroplane in the history of the world capable of sustained free flight."

Though the matter of the label is not now an issue, it seems only fair to the Institution to say that in September 1928, Secretary Abbot finally caused the label of the Langley machine to be changed to read simply as follows:

LANGLEY AERODROME

THE ORIGINAL SAMUEL PIERPONT LANGLEY
FLYING MACHINE OF 1903, RESTORED.

Deposited by
The Smithsonian Institution

301,613

This change has frequently been overlooked by writers on the controversy.

[2] Smithsonian Reports: 1914, pp. 9, 219, 221, 222; 1915, pp. 14, 121; 1917, p. 4; 1918, pp. 3, 28, 114, 166. Report of U. S. National Museum, 1914, pp. 42 and 47.

[2] Smithsonian Reports: 1914, pp. 9, 219, 221, 222; 1915, pp. 14, 121; 1917, p. 4; 1918, pp. 3, 28, 114, 166. Report of U. S. National Museum, 1914, pp. 46 and 47.

In January 1942, Mr. Fred C. Kelly, of Peninsula, Ohio, communicated to me a list of differences between the Langley plane as tested in 1914 and as tested in 1903, which he had received from Dr. Wright. This list is given verbatim below. The Institution accepts Dr. Wright's statement as correct in point of facts. Inferences from the comparisons are primarily the province of interested experts and are not discussed here.

COMPARISON OF THE LANGLEY MACHINE OF 1903 WITH THE HAMMONDSPORT MACHINE OF MAY-JUNE, 1914.

	LANGLEY, 1903.	HAMMONDSPORT, 1914.
	WINGS.	
1	SIZE: 11'6" x 22'6" (L.M. p. 206)	SIZE: 10'11¾" x 22'6"
2	AREA: 1040 sq. ft. (L.M. p. 206)	AREA: 988 sq. ft.
3	ASPECT RATIO: 1.96	ASPECT RATIO: 2.05
4	CAMBER: 1/12 (L.M. p. 205)	CAMBER: 1/18
5	LEADING EDGE: Wire 1/16" diameter (L.M. Pl.66)	LEADING EDGE: Cylindrical spar 1½" dia. at inner end, tapering to 1" dia. at outer end.
6	COVERING: Cotton fabric, not varnished.	COVERING: Cotton fabric, varnished.
7	CENTER SPAR: Cylindrical wooden spar, measuring 1½" dia. for half its length and tapering to 1" at its tip. (L.M. p. 204). Located on upper side of wing.	CENTER SPAR: Cylindrical spar about 1½" dia. at inner end, tapering to about 1" dia. at outer end. Located on upper side of wing. This center spar was reinforced (1) by an extra wooden member on the under side of the wing, which measured 1" x 1½" and extended to the 7th rib from the center of the machine; and (2) by another wooden reinforcement on the under side extending out about one-fourth of the length of the wing.
8	RIBS: Hollow box construction. (L. M. Plates 66,67)	RIBS: Most of the original Langley box ribs were replaced with others made at Hammondsport. (Manly letter, 1914). The Hammondsport ribs were of solid construction and made of laminated wood. That part of the rib in front of the forward spar was entirely omitted.

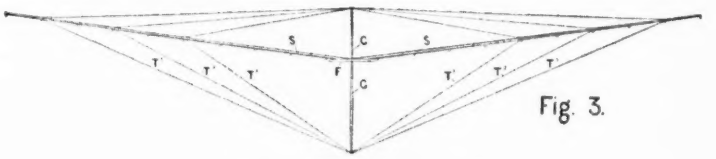


Fig. 3.

LANGLEY WING TRUSSING 1903.

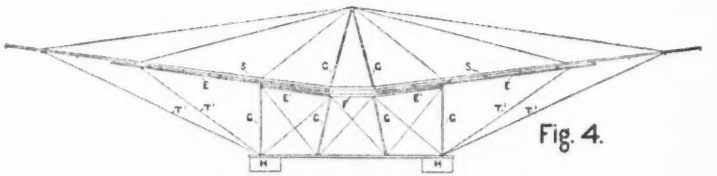


Fig. 4.

HAMMONDSPORT WING TRUSSING 1914.

9	LOWER GUY-POSTS: A single round wooden post for each pair of wings (see Fig. 3), 1¼" in dia. 6½' long. (L.M. Plate 62, p. 184).	LOWER GUY-POSTS: Four for each pair of wings (see Fig. 4), two of which were of streamline form measuring 1¼" x 3½" x 54" long; and two measuring 2" x 2" with rounded corners, 3'9" long.
10	The front wing guy-post was located 28½" in front of the main center spar. (L.M. Plate 53).	The front wing guy-posts were located directly underneath the main center spar, 28½" further rearward than in 1903.
11	The rear wing guy-post was located 31½" in front of the main center spar. (L.M. Plate 53).	The rear wing guy-posts were located directly under the main center spar, 31½" further rearward than in 1903.
12	UPPER GUY-POSTS: For each pair of wings a single steel tube ¾" dia., 43" long. (L.M. p. 184, pl. 62).	UPPER GUY-POSTS: For each pair of wings, two streamline wooden posts each 1¼" x 3½", 76" long, forming an inverted V. (See Fig. 4).
13	Front wing upper guy-post located 28½" in front of the main center spar. (L.M. pl. 53).	Front wing upper guy-posts located directly over main spar, 28½" further rearward than in 1903.
14	The rear wing upper guy-post was located 31½" in front of the main center spar. (L.M. pl. 53).	The rear wing guy-posts were located directly over the main center spar, 31½" further rearward than in 1903.
15	TRUSSING: The wing trussing wires were attached to the spars at the 5th, 7th and 9th ribs out from the center (L.M. pl. 54). The angles between these wires	TRUSSING: A different system of wing trussing was used, and the wing trussing wires were attached to the spars at the 3rd, 6th and 9th ribs from the center. The angles between these wires

	and the spars to which they were attached are shown in Fig. 3.	and the spars to which they were attached were all different from those in the original Langley machine. (See Fig. 4).
	CONTROL SURFACES.	
16	VANE RUDDER: A split vane composed of two surfaces united at their leading edges and separated 15" at their trailing edges, thus forming a wedge. Each surface measured 2'3" x 4'6", with aspect ratio .5. (L.M. p. 214, pls. 53,54).	VERTICAL RUDDER: The Langley vane rudder was replaced by a single plane vertical rudder which measured 3'6" x 5', with aspect ratio of .7.
17	Operated by means of a wheel located slightly in front of the pilot at his right side and at the height of his shoulder (L.M. p. 216, pls. 53,54).	Operated at Hammondsport through the Curtiss steering wheel in some tests, (Zahm affidavit pp. 5, 6), through the Curtiss shoulder yoke in some others (Manly letter, 1914), and fixed so as not to be operable at all in still others, (Zahm affidavit p. 7).
18	Used for steering only. (L.M. p. 214).	Used "as a vertical aileron to control the lateral poise of the machine", (Zahm affidavit p. 6) as well as for steering, (Zahm affidavit p. 7).
19	PENAUD TAIL: This was a dart-shaped tail having a vertical and a horizontal surface (Penaud tail), each measuring 95 sq. ft. It was located in the rear of the main frame.	TAIL RUDDER: Same size and construction as in 1903.
20	Attached to a bracket extending below the main frame.	Attached to same bracket at a point about 8" higher than in 1903.
21	"Normally inactive", (L. M. p. 216) but adjustable about a transverse horizontal axis by means of a self-locking wheel located at the right side of the pilot, even with his back, and at the height of his shoulder. (L.M. pls. 51, 53).	Operable about a transverse horizontal axis and connected to a regular Curtiss elevator control post directly in front of the pilot (Zahm affidavit p. 5).
22	Immovable about a vertical axis. (L.M. p. 214, pl.56, Fig. 1). No means were provided for adjusting this rudder about a vertical axis in flight. "Although it was	Immovable about a vertical axis on May 28, 1914, only. Thereafter it was made movable about a vertical axis and was connected through cables to a Curtiss steering wheel mounted on a

	necessary that the large aerodrome should be capable of being steered in a horizontal direction, it was felt to be unwise to give the Penaud tail and rudder motion in the horizontal plane in order to attain this end". (L.M. p. 214).	Curtiss control post directly in front of the pilot.
23	KEEL: A fixed vertical surface underneath the main frame measuring 3'2" in height by 6' average length. Area 19 sq. ft. (L.M. pl. 53).	KEEL: Entirely omitted.
	SYSTEM OF CONTROL.	
24	LATERAL STABILITY: The dihedral only was used for maintaining lateral balance. (L.M. p. 45).	LATERAL STABILITY: Three means were used for securing lateral balance at Hammondsport: The dihedral angle as used by Langley, a rudder which "serves as a vertical aileron" (Zahm affidavit p. 6), and the Penaud tail rudder. The last two constituted a system "identical in principle with that of Complainant's [Wright] combined warping of the wings and the use of the vertical rudder". (Zahm affidavit p. 6).
25	LONGITUDINAL STABILITY: Langley relied upon the Penaud system of inherent stability for maintaining the longitudinal equilibrium. "For the preservation of the equilibrium [longitudinal] of the aerodrome, though the aviator might assist by such slight movements as he was able to make in the limited space of the aviator's car, the main reliance was upon the Penaud tail." (L.M. p. 215).	LONGITUDINAL STABILITY: At Hammondsport the Penaud inherent longitudinal stability was supplemented with an elevator system of control.
26	STEERING: Steering in the horizontal plane was done entirely by the split-vane steering rudder located underneath the main frame. (L.M. p. 214).	STEERING: On one day, May 28, 1914, steering in the horizontal plane was done with the vertical rudder which had been substituted for the original Langley split-vane steering rudder. After May 28th the steering was done by the vertical surface of the tail rudder (Zahm affidavit p. 7), which in 1903 was immovable about a vertical axis, (L.M. p. 214).

ing this rudder about a vertical axis in flight. "Although it was

and was connected through cables to a Curtiss steering wheel mounted on a

1903 was immovable about a vertical axis, (L.M. p. 214).

POWER PLANT.

27	MOTOR: Langley 5 cylinder radial.	MOTOR: Langley motor modified.
28	IGNITION: Jump spark with dry cell batteries. (L.M. p. 262).	IGNITION: Jump spark with magneto.
29	CARBURETOR: Balzer carburetor consisting of a chamber filled with lumps of porous cellular wood saturated with gasoline. The air was drawn through this wood. There was no float feed. (L.M. p. 225).	CARBURETOR: Automobile type with float feed.
30	RADIATOR: Tubes with radiating fins.	RADIATOR: Automobile radiator of honeycomb type.
31	PROPELLERS: Langley propellers (L.M. pl.53, pp. 178-182).	PROPELLERS: Langley propellers modified "after fashion of early Wright blades".

LAUNCHING AND FLOATS.

32	LAUNCHING: Catapult mounted on a houseboat.	LAUNCHING: Hydroplanes, developed 1909-1914, attached to the machine.
33	FLOATS: Five cylindrical tin floats, with conical ends, attached to underside of main frame at appropriate points, and about six feet above lowest part of machine.	FLOATS: Two wooden hydroplane floats, mounted beneath and about 6 feet to either side of the center of the machine at the lateral extremities of the Pratt system of trussing used for bracing the wing spars of the forward wings; and one (part of the time two) tin cylindrical floats with conical ends, similar to but larger than the Langley floats, mounted at the center of the Pratt system of trussing used for bracing the rear wings. All of the floats were mounted from four to five feet lower than the floats of the original Langley, thus keeping the entire machine above the water.

WEIGHT.

34	TOTAL WEIGHT: With pilot 850 pounds (L.M. p. 256).	TOTAL WEIGHT: With pilot, 1170 pounds.
35	CENTER GRAVITY: 3/8" above line of thrust.	CENTER GRAVITY: About one foot below line of thrust.

Since I became Secretary, in 1928, I have made many efforts to compose the Smithsonian-Wright controversy, which I inherited. I will now, speaking for the Smithsonian Institution, make the following statement in an attempt to correct as far as now possible acts and assertions of former Smithsonian officials that may have been misleading or are held to be detrimental to the Wrights.

1. I sincerely regret that the Institution employed to make the tests of 1914 an agent who had been an unsuccessful defendant in patent litigation brought against him by the Wrights.

2. I sincerely regret that statements were repeatedly made by officers of the Institution that the Langley machine was flown in 1914 "with certain changes of the machine necessary to use pontoons", without mentioning the other changes included in Dr. Wright's list.

3. I point out that Assistant Secretary Rathbun was misinformed when he stated that the Langley machine "without modification" made "successful flights".

4. I sincerely regret the public statement by officers of the Institution that "The tests" [of 1914] showed "that the late Secretary Langley had succeeded in building the first aeroplane capable of sustained free flight with a man."

5. Leaving to experts to formulate the conclusions arising from the 1914 tests as a whole, in view of all the facts, I repeat in substance, but with amendments, what I have already published in Smithsonian Scientific Series, Vol. 12, 1932, page 227:

> The flights of the Langley aerodrome at Hammondsport in 1914, having been made long after flying had become a common art, and with changes of the machine indicated by Dr. Wright's comparison as given above, did not warrant the statements published by the Smithsonian Institution that these tests proved that the large Langley machine of 1903 was capable of sustained flight carrying a man.

6. If the publication of this paper should clear the way for Dr. Wright to bring back to America the Kitty Hawk machine to which all the world awards first place, it will be a source of profound and enduring gratification to his countrymen everywhere. Should he decide to deposit the plane in the United States National Museum, it would be given the highest place of honor, which is its due.

"IT is of the greatest importance that this Society, in its position as the oldest aeronautical body in the world, shall have its records truthfully maintained".

Griffith Brewer

In an address to the Society on October 20 1921.

TECHNICAL NOTES

Contributions to this Section of the JOURNAL *will be eligible for Journal Premium Awards and will normally be published within two months of being received.*

Definition of Specific Impulse

by

S. W. GREENWOOD, A.F.R.Ae.S.

IN ROCKETRY, the definition of Specific Impulse is given variously as Thrust per unit mass of propellants consumed per second[1] and Thrust per unit weight of propellants consumed per second[2,3]. The second definition is convenient in giving units in seconds, but is unsatisfactory in that the weight of a given mass of propellants depends upon gravitational attraction, and decreases with altitude.

Can we persuade the rocket people to standardise on the first, and logical, definition, and adopt the units (lb. force × sec.)/(lb. mass) in the fast-pound-second system?

Received October 1953.

REFERENCES

1. PERRING, W. G. A. (1946). A Critical Review of German Long-Range Rocket Development. *Journal of the Royal Aeronautical Society*, July 1946.
2. CLEAVER, A. V. (1951). Rockets and Assisted Take-Off. *Journal of the Royal Aeronautical Society*, February 1951.
3. DIPLOCK, B. R. and others (1953). Liquid Propellant Rocket Motors. *Journal of the Royal Aeronautical Society*, January 1953.

*Some Measurements of Leading Edge Separation Bubbles on a 10 per cent Thick Symmetrical Aerofoil**

by

J. BLACK, Ph.D. AND R. D. HUNT, B.Sc.
(University of Bristol, Department of Aeronautical Engineering)

PRESSURE DISTRIBUTION and liquid-film tests on a 10 per cent. thick aerofoil revealed the presence of separation "bubbles" close to the leading edge[1]. These bubbles are formed beneath the boundary layer which separates near the leading edge and re-attaches farther aft; their existence is usually indicated by localised constant-pressure regions in the pressure distributions. It is also believed that if a thin film of liquid (such as a suspension of lamp-black in paraffin) is spread on the surface, the scrubbing action of the air rotating in the bubble will tend to draw liquid forward into the bubble, and hence the location and extent of the bubble may be indicated approximately by the accumulation of the fluid.

Many boundary layer traverses of bubbles on N.A.C.A. aerofoils have been made[2,3,4,5], but it was felt that similar measurements of the bubbles on this particular aerofoil would provide useful data, since the separation characteristics of this section appeared to differ from those in the N.A.C.A. tests.

1. APPARATUS AND TESTS

The section was symmetrical, with 10 per cent. maximum thickness at 40 per cent. chord, and nose radius of 0·7 per cent. chord radius. The model, with a chord of 12·75 in., was tested in an open-jet wind tunnel at a Reynolds number of $0{\cdot}6 \times 10^6$.

For the total head traverse many small open-ended tubes were tried and rejected, largely because of slow response, or liability to collapse when in contact with the model surface at the limit of traverse. Finally, a steel tube of 0·04 in. outside diameter and wall thickness 0·005 in. was flattened over a 0·005 in. tongue, and one wall was honed under a microscope to 0·001 in. thickness. The thickness of the remaining walls prevented collapse (Fig. 1). This tube was soldered into a larger bore tube which could be traversed normal to the surface by a small micrometer set into the opposite side of the model. Good accuracy of location and rigidity of the tube mouth were obtained with this method of mounting.

Total head traverses were made at various chordwise locations in the vicinity of the bubble for the incidence range 4° to 12°. Where the recorded pressure was unsteady its average range was noted. Local surface static pressures were obtained from Ref. 1.

2. RESULTS

Normally a boundary layer is assumed to transmit the static pressure of the free stream outside it, and the velocity distribution within the layer may be represented by the relation

$$\frac{u}{U} = \sqrt{\left(\frac{H_b - p}{H - p}\right)},$$

where the suffix "b" refers to quantities within the layer (Fig. 2).

This assumption (and therefore the assumption that $p = p_b$) has been made in plotting the boundary layer profiles in this test, as in previous tests[2,3]. It is not known to what extent it is true for the separation bubble,

*The experiments upon which this note is based were made by Mr. R. D. Hunt in part requirement for the degree of B.Sc. in Engineering with Honours of the University of Bristol.

Received 6th November 1953

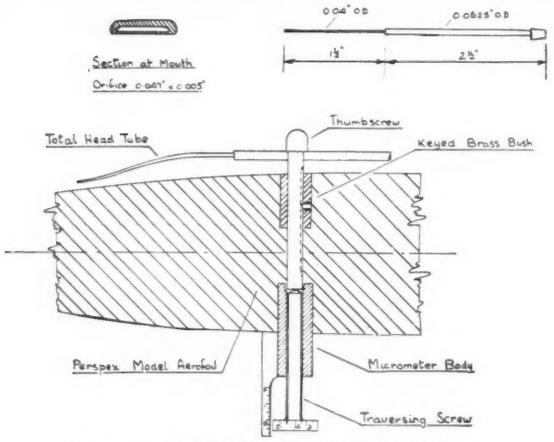


FIGURE 1. Sketch of total head tube installation.

since strictly the following relation should be used

$$\frac{u}{U} = \sqrt{\left(\frac{H_b - p_b}{H - p}\right)}.$$

It is possible that the circulation which is understood to be set up within the separation bubble may cause a decrease in the static pressure as in the core of a weak vortex. Fig. 2 indicates the effect of a small negative static pressure peak on a typical boundary layer profile

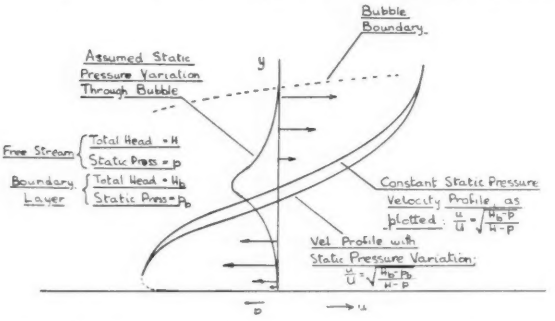


FIGURE 2. Illustration of effect of static pressure variation through bubble on velocity profile derived from total head measurements.

as found in the tests. It can be seen that the error in the plotted boundary layer profile due to this static pressure variation is not large, because the pressure peak will coincide with the point of zero velocity, where the gradient of the profile dy/du is small.

2.1. *Boundary layer measurements*

The boundary layer profiles deduced as above near the leading edge of the aerofoil at various incidences are shown in Fig. 3. As mentioned previously, these profiles are based on the assumption of constant static pressure. They are also only approximate in the region of reversed flow, where the pitot tube does not register accurately.

At all the incidences covered, the curves exhibit the features of a region of laminar separation, namely, zero velocity occurring at a point above the aerofoil surface and a reversed flow between this point and the surface. It will be noted that in each case zero velocity occurs at or near the "points" of greatest range of variation. Large low-frequency oscillations in velocity have previously been detected in this region using a hot-wire anemometer[4].

Unfortunately, the boundary layer surveys could not be extended either forward or aft of the bubble sufficiently to contain the wholly laminar and turbulent layers. It is difficult to assess the flow condition from the observed boundary layer profiles near the separation bubble.

The height of the layer underlying separated flow was taken as the position of zero velocity at each chordwise station. This is an arbitrary boundary which is merely convenient experimentally, as obviously the field of flow cannot be divided into two distinct regions. Fig. 4 shows the shapes of the laminar separation bubbles deduced from the zero velocity points in Fig. 3. From 4° to 8° incidence, the bubble moves forward and becomes shorter in chordwise extent but of greater height above the surface. At 10° a change occurs, the bubble becoming longer and shallower again. With increase of incidence from 10° to 12°, the bubble grows with the rear edge moving rapidly aft, and increases in height. An unusual feature is that ahead of the bubble, at $0{\cdot}02c$, the zero-velocity points of the traverse appear to move away from the surface with increase in incidence, almost as if a new bubble were growing ahead of the main bubble. It is possible that this effect arises from a strong static pressure variation normal to the surface, which may be very pronounced in this region of sharp curvature.

Boundary layer measurements at 14° incidence were attempted, but the readings were extremely erratic and could not be recorded, indicating a stalled condition.

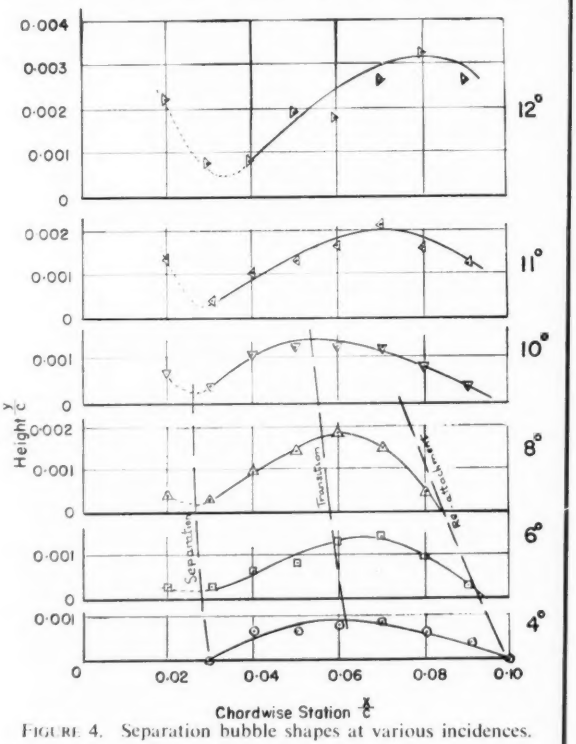


FIGURE 4. Separation bubble shapes at various incidences.

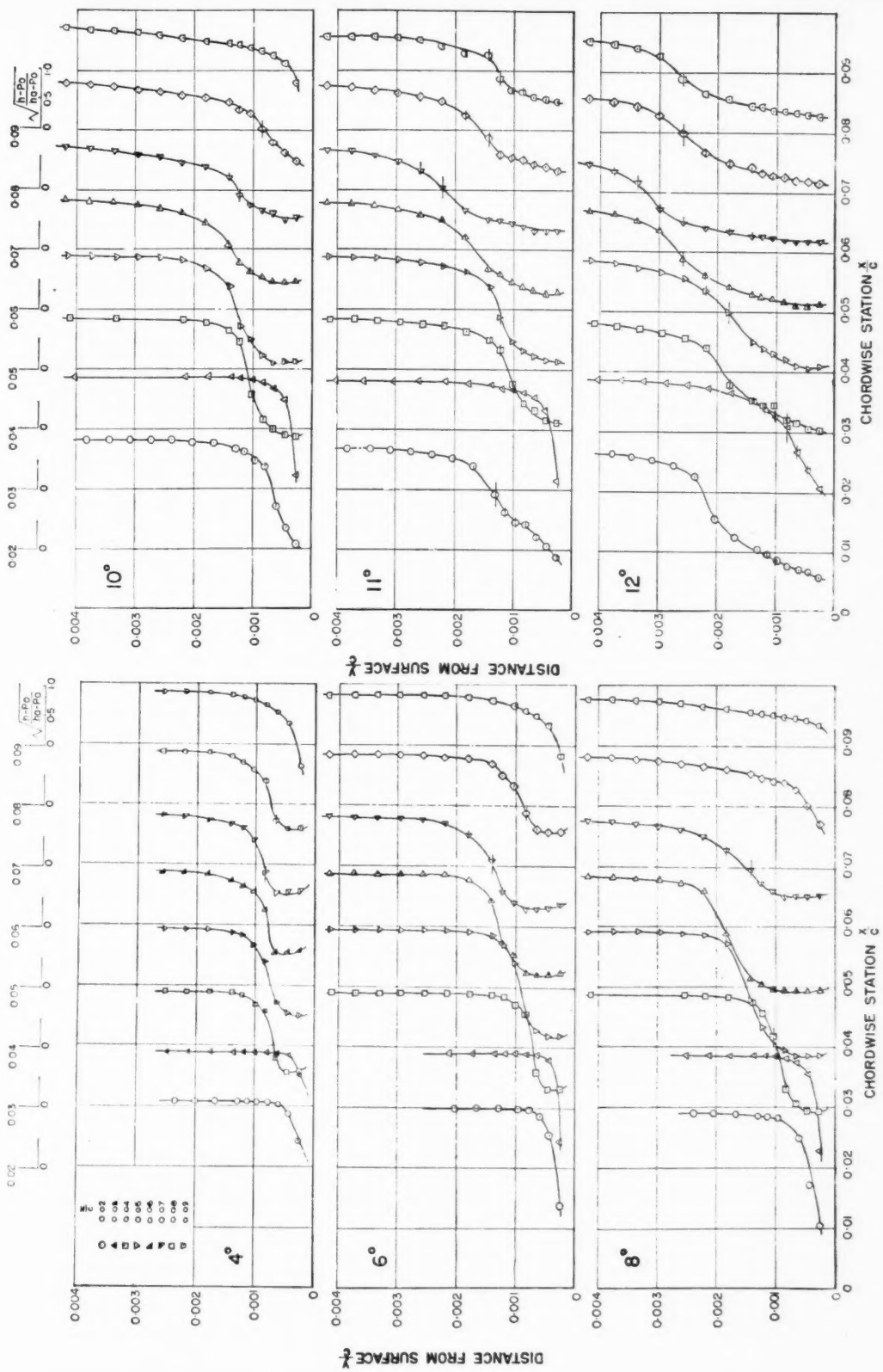


FIGURE 3. Approximate boundary layer profiles at various incidences.

The mechanism of the re-attachment is as follows: the laminar layer separates from the surface, leaving it tangentially. At some point farther aft away from the surface, transition occurs and the turbulent layer proceeds to spread in a wedge of approximately 6° included angle[4]. Where this turbulent wedge intersects the surface still farther aft re-attachment occurs. The locations of separation, transition and re-attachment in Fig. 4, are based on this conception of the bubble formation.

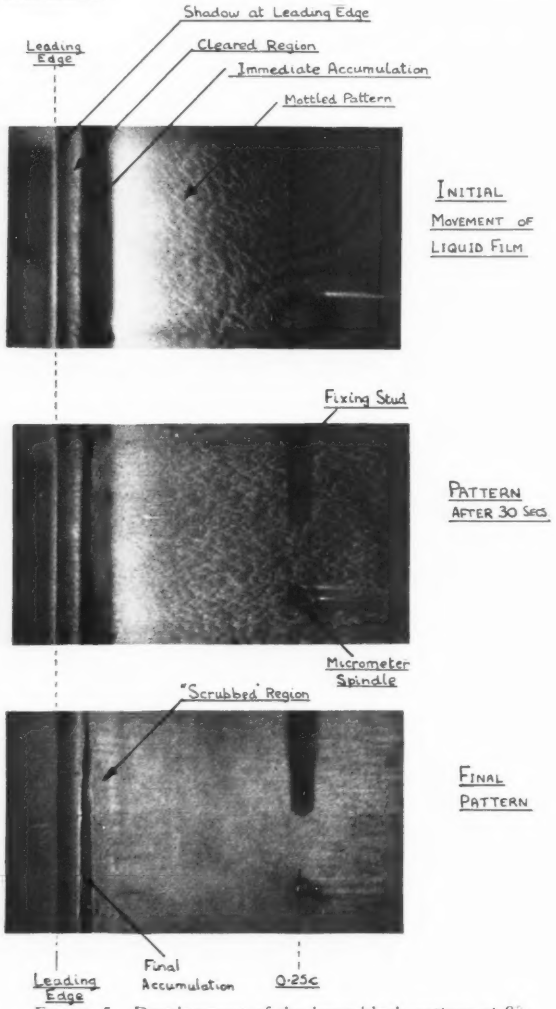


FIGURE 5. Development of the lamp-black pattern at 8° incidence.

2.2. *Liquid-film studies*

At 4° incidence, the wing was swept clean of lamp-black from the leading edge back to 0·060*c*. There was no sign of a lamp-black band to suggest the presence of the laminar separation bubble indicated by boundary layer measurements at 4°.

A broad band of lamp-black accumulated at both 6° and 8°, and immediately the liquid in the rear portion of the band started to flow forward into the upstream portion. After about a minute's run and thereafter, only a much narrower band remained, although the

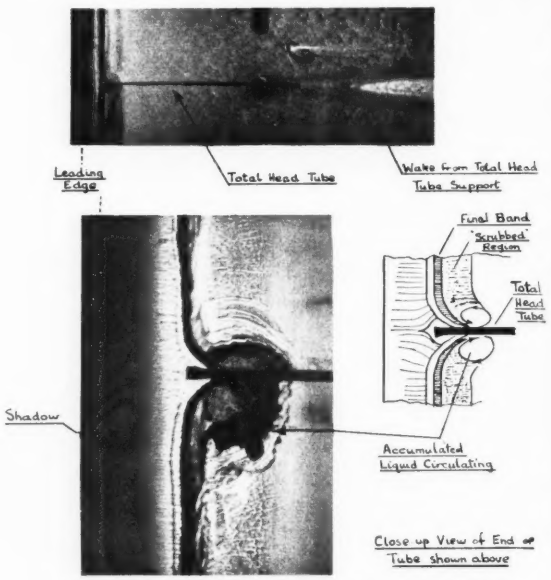


FIGURE 6. Effect of total head tube on liquid film.

"scrubbed" region was still faintly discernible. The liquid in the final band remained almost stationary, except for slight movement in the ragged rear edge. The forward edge was quite steady and well defined. Three stages in the development of the lamp-black band at 8° incidence are shown in Fig. 5(*a*), (*b*) and (*c*).

With increase of incidence to 10°, two bands of lamp-black appeared; one similar to that at 6° and 8°, and another threadlike band almost on the leading edge. At 11° and 12° only the thin leading edge line existed.

These visual tests suggested that, with increasing incidence from 4° to 10°, the separation bubble moved forward, while from 10° to 12° a small leading edge bubble was formed.

Downstream of the separation bubble there existed a short area clear of lamp-black merging into a region of mottled appearance. This mottled appearance arises from surface waves produced on the initial comparatively thick liquid film; it gradually disappears as the liquid evaporates, or is swept rearwards. Comparison with similar mottling produced on the aerofoil under-surface, where there is no separation of flow, suggests that such mottling indicates re-attachment of flow.

It was found that the presence of the total head tube disturbed the lamp-black accumulation, even when the tube was 0·001*c* (0·013 in.) above the surface. The effect at 8° is shown in Fig. 6, the tube being 0·0005*c* from the surface. The line of lamp-black is turned downstream on each side of the tube mouth. It will be noticed that the displaced band remains normal to the line of flow of the air stream passing the nose of the tube. The appearance of a small thread of lamp-black immediately in front of the main band is extremely interesting, but no explanation for its existence can be offered.

With the tube in position at 10° incidence, only the thin leading edge line was observed. Several smaller tubes (down to 0·015 in. diameter) were tested and were found to cause similar, but less extensive, disturbances.

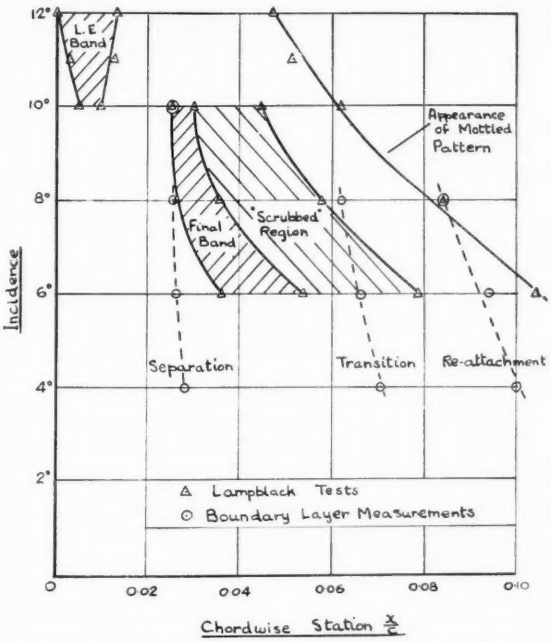


FIGURE 7. Variation in chordwise extent of separation bubble with incidence.

The interference from the tube indicated by the lamp-black pattern casts some doubt on the meaning of total head reading made within the bubble, but the approximate location of the zero velocity region should not be affected.

An attempt to relate the indications of the extent of bubble from the total head traverses and the lamp-black tests is made in Fig. 7. In the total head measurements the location of separation, transition and re-attachment have been assumed as suggested by Fig. 4, and for the lamp-black patterns the location of the final dark band, the "scrubbed" region and the boundary of the mottled pattern were measured accurately on the model.

Between 6° and 10° the agreement is reasonably good, but the liquid film failed to indicate the existence of a bubble at 4°. Above 10° it was impossible to make any total head measurements close to the leading edge, and the lamp-black indicated a bubble, which grew wider with increase in incidence. The main difficulty here is the interpretation of the movement of the liquid film, since it is not yet clear whether the film requires a critical tractive effort from the rotating air in the bubble before it moves, or whether in fact it also moves partly under the influence of pressure gradients, which at 4° incidence were insufficient to provoke any movement of the film.

Comparison with the location and extent of the constant-pressure regions in the pressure distributions suggests that the bubble extends much farther aft than the limit of the constant pressure. Care should therefore be used in analysing the formation of "short" or "long" bubbles solely on the indications of the pressure distributions.

A limitation on the usefulness of the data from these tests is the comparatively low Reynolds number, but it has been thought useful to report the results in the hope that interest in the phenomena described may stimulate similar investigations at higher Reynolds number.

REFERENCES

1. BLACK, J. (1953). Pressure Distribution and Boundary Layer Investigations on a 44° Sweptback Wing. Part II: Two-Dimensional Pressure Distribution Tests on a 10 per cent. Thick Symmetrical Aerofoil Section. A.R.C. Current Paper No. 137 (*to be published*).
2. GAULT, D. E. (1949). Boundary Layer and Stalling Characteristics of the N.A.C.A. 63-009 Airfoil Section. N.A.C.A. T.N. 1894, June 1949.
3. MCCULLOUGH, G. B. and GAULT, D. E. (1949). Boundary Layer and Stalling Characteristics of the N.A.C.A. 64 A. 006 Airfoil Section. N.A.C.A. T.N. 1923, August 1949.
4. BURSNALL, W. J. and LOFTIN, L. K. (1951). Experimental Investigation of Localised Regions of Laminar Boundary Layer Separation. N.A.C.A. T.N. 2338, April 1951.
5. MCCULLOUGH, G. B. and GAULT, D. E. (1951). Examples of Three Representative Types of Airfoil Section Stall at Low Speed. N.A.C.A. T.N. 2502, September 1951.

Optimum Conditions for the Operation of Airline Aircraft

by

J. M. STEPHENSON

(*Division of Engineering, Brown University, U.S.A.*)

IN A. H. Stratford's interesting note in the August JOURNAL, he assumes that an airline is presented with an aircraft of given performance, and must decide what is the best range for it to fly. Surely the practical case is the exact opposite: that an operator wishes to carry passengers or freight between two given points, and must choose between perhaps three or four available types of aircraft. Moreover, it is up to the operator to tell the manufacturers which feature he wants improved (*e.g.* fuel consumption, take-off distance, and so on), when he is ready to order replacements.

Secondly, Mr. Stratford wishes to replace the usual concept of direct operating cost per payload ton mile by that of per cent. profit, as a measure of the efficiency of operation over a certain route. While this may be a more realistic approach to the problem of a private airline company, operating over a single route, its merit is not so obvious for the large national or subsidised airlines, which are often required to fly unprofitable routes. But the chief disadvantage of the proposed criterion is that it requires a knowledge of the indirect costs (advertising, administration, and so on) *as a function of range*. The return for these costs is shown up mainly in the load factor, and I very much doubt whether this effect is yet calculable with an accuracy at all comparable with that for the direct costs. For example, can any advertising man say by what fraction

Received 7th October 1953.

he must increase his expenditure to increase the load factor on a given route from 70 to 71 per cent.? It is certainly unsatisfactory to work out carefully the direct costs, and then "approximately double" them, and the present method of keeping separate the technical and business matters may be the best.

However, the most interesting result of the analysis is probably true: ". . . a range considerably less than that giving the optimum [he means *maximum*] ton miles per flight will give the best return for airline operation." This seems to be another example of the well-known economic maxim that the greatest profit is always obtained by selling a smaller quantity than that giving the greatest revenue.

A. H. STRATFORD
(British European Airways)

THE COMMENTS of Mr. J. M. Stephenson are of interest in emphasising the advantages of the "direct" method of estimating transport aircraft costs.

It is true that a frequent task before the airline engineer is to compare various competitive aircraft types but it is seldom now the simple case of carrying passengers and freight between two points, as he suggests. The problem has become a more complex one, and I have attempted to explore one side of it which I believe to be infrequently considered. We are not in need of another method of simplified cost comparison but are finding it increasingly important to evaluate the commercial potential of particular aircraft, especially when driven by new propulsive systems giving widely varying performance. This is I think largely because on a complex route system a given aircraft type may be most effectively utilised in a radically different way from its competitor.

It is agreed that the operator is often in a position to say that he wants certain characteristics improved, but it would be bold to suggest that the striking increases in take-off weight, capacity, range and performance of the present generation of transport aircraft have resulted from simple economic calculations.

We can be aided, however, by a quantitative assessment of the potential economic value of significant transport types developed to a stage which is within our technical grasp. In recent years it has become increasingly clear that this potential value must be measured in terms of revenue as well as of cost.

The use of payload in computing the specific cost figure does not amount to an assessment of revenue earning capacity. Two aircraft with the same direct cost per unit of payload, but of different size, will have widely different applications to the airline operator; the smaller aircraft being able to operate economically at higher frequency and with greater flexibility, but one unit will of course have a lower revenue earning capacity in a given time. In few particulars are the aircraft comparable at all. A difference in cruising speed will invalidate the comparison in a similar way.

As Mr. Stephenson rightly says, large national and subsidised airlines may be required to fly unprofitable routes, but the art of all transport management lies surely in the ability to operate both profitable and unprofitable routes with maximum overall advantage, which demands an imaginative integration of the whole route system and a very complete understanding of the route capabilities of its aircraft types.

Mr. Stephenson's comment on the chief disadvantage of the proposed criterion, that it requires a knowledge of the indirect costs as a function of range, and therefore of route, is a very illuminating one. It is because it is so difficult a task that it has generally been ignored, and it may indeed be ignored with still useful results so long as the revenue-earning potential is included in the criterion. But just as total costs, as well as revenue, need to be known for a final analysis of airline economy, so the limitation of fleet replacement studies to a consideration of direct costs alone may be simplifying but can be often misleading. Also, revenue-earning capacity and indirect costs have an important effect on the route length for maximum economy of any type of transport aircraft. The difficulties in the assessment of load factor and overheads do not invalidate the principle.

There is generally little difficulty in estimating revenue-earning capacity, since payload, block speeds and fare rates can readily be computed. Load factors are much more difficult to forecast but useful results can be obtained by assuming constant mean values.

The essential point is that, while the simple case of a point-to-point route operated by two aircraft of similar type may be usefully considered on the basis of direct costs alone, the problem of frequent occurrence today, where competitive aircraft of different size and performance provide the required overall capacity, may demand consideration of widely varying route integration patterns involving different sales appeal and load factors, perhaps different seating densities, fares and station costs. One solution might well necessitate the operation of one less type of aircraft in the fleet: this would react immediately on engineering and introduction costs. Such matters cannot be ignored.

The object of my brief note was not only to propose a surer yardstick for the comparison of new transport aircraft projects, but to establish the best conditions for the operation of new projects so that they can be most effectively compared with each other. It is clear that the permutations possible in the planning of schedules for a particular airline play a critical part in the final solution, and simple cost parameters give insufficient insight into the significant variables at work.

Undoubtedly the "type" or "direct" costs criterion will continue to be used for many comparisons, but it is important that its limitations be known and that evaluation of revenue potential and total costs on a route basis should be made when more exact results are required.

Mr. Stephenson emphasises one result of the analysis, rightly suggesting the word "maximum" in the text rather than "optimum." This result is important but is well known. What I believe to be of far more significance is the result that routes considerably longer than those giving the minimum direct costs per ton mile will provide the best return in airline operations.

THE LIBRARY

A Preview and Reviews

THE PAPERS OF WILBUR AND ORVILLE WRIGHT.

Edited by Marvin W. McFarland. Two volumes. McGraw Hill Book Company, Inc. New York. 1953. $20.

Editorial Note: By courtesy of the publishers a set of uncorrected galley proofs of *The Papers of Wilbur and Orville Wright* was sent to the Royal Aeronautical Society so that the latest possible information would be available to check the tribute which is paid to the brothers in this issue of the JOURNAL. As these galleys are uncorrected proofs and are without the illustrations, the following is less in the nature of a review than of a preview of volumes due for publication a few days after the December JOURNAL has gone to press. It is hoped to give technical reviews of the Papers by authorities on various aspects of this most remarkable story, which is only now being told in its entirety.

Following the death of Orville Wright on January 30 1948, all the Wright papers were deposited in the Library of Congress, Washington. These papers will not be fully accessible to students of aeronautics until 1960, but the executors are allowing the publication of as much technical and general material as early as possible. There are some thirty thousand items in the Wright letter files alone, an indication of the tremendous task of sorting and classifying which is required.

In 1951 Fred C. Kelly, a friend of Orville Wright, published *Miracle at Kitty Hawk*, in which appeared a selection from the Wright letters for the general reader. Letters which dealt with technical matters in detail were largely omitted.

In the present two volumes, Marvin W. McFarland, who is the special consultant to the chief of the Aeronautics Division of the Library of Congress, has made his selection of material to show the technical achievements of the Wrights. Publication of these documents reveals, even on the cursory inspection which can only be given at the present stage, that Wilbur and Orville Wright were men apart in their fundamental outlooks, their clear approaches to intricate problems, and their extreme integrity in all their statements of their work.

These volumes include not only letters dealing with technical matters, but the diaries of the brothers, their wind tunnel tables and propeller notebooks and their notes. Here is given all the correspondence between the Wrights and Octave Chanute during the years 1900-1910; 33 diaries and notebooks of the Wrights from 1900-1919; abstracts from Chanute's letters to his many correspondents about the Wrights; and the Wrights own correspondence. Also included are extracts from the diaries of the Wrights' father, Bishop Milton Wright, and selected articles and lectures by the two brothers.

These volumes are the most important yet published in the short but urgent history of aeronautics. The world has waited fifty years for the greater part of the technical information which now appears for the first time. The Royal Aeronautical Society has played a not inconsiderable part by obtaining some of that information in advance through the medium of the Wilbur Wright Memorial Lectures, to which acknowledgment is paid in the many explanatory notes.

Volume I covers the critical period of gliding and the development of the first aircraft prototypes, the years 1899-1905. In this volume appears the astonishing correspondence between the Wrights and Octave Chanute, a correspondence which not only reveals the way the minds of the brothers worked, but the step by step arguments which led to their final conclusions. This correspondence alone will settle for all time the suggestion that the brothers had been lucky in being the first to fly a power driven controlled aeroplane, or the suggestion that they had learnt enough from previous experimenters to apply that knowledge to enable them to fly. Neither suggestion is true.

These letters are, indeed, the written technical discussions showing an ordered plan for the design, construction, testing, development and trials of a new form of transport. They are discussions of a very high order.

Wilbur Wright's first letter, dated May 13 1900, to Octave Chanute, began, "For some years I have been afflicted with the belief that flight is possible to man. My disease has increased in severity and I feel that it will soon cost me an increased amount of money if not my life. . . . I will proceed to describe the plan and apparatus it is my intention to test. In explaining these, my object is to learn to what extent similar plans have been tested and found to be failures, and also to obtain such suggestions as your great knowledge and experience might enable you to give me."

In that lengthy letter Wilbur Wright explained his now famous method of warping the wings to obtain lateral control and discussed the reasons for the failure of Lilienthal and other experimenters to retain control of their gliders. Chanute, impressed by Wilbur's letters, replied immediately and expressed his willingness to help in any way he could.

In 1911 Orville wrote of Chanute, who had died in the previous November,

"His writings were so lucid as to provide an intelligent understanding of the nature of the problems of flight to a vast number of persons who would probably never have given the matter study otherwise, and not only by published articles but by personal correspondence and visitation, he inspired and encouraged to the limits of his ability to all who were devoted to the work."

Chanute not only gave advice but paid visits to Kitty Hawk to add practical advice on the spot. His name will always be linked, and deservedly so, with those years of development, 1900-05. "His private correspondence with experimenters in all parts of the world was of great value," added Orville. "No one was too humble to receive a share of his time. In patience and goodness of heart he has rarely been surpassed."

In these letters between Chanute and the Wrights, and in the latters' diaries, particulars of hundreds of glides and tests are given and discussed. The particulars nearly all give the angle of glide, wind speed and ground speed and weight of glider and pilot and other details enabling conclusions of value to be drawn for future work. Comparison with the early work of Chanute himself is discussed and figures worked out for the lift and drag and movements of the centre of pressure, and so on, and these figures are compared with those obtained by other workers on the problems involved.

On the return of the brothers from their first brief gliding experiences at Kitty Hawk in 1900, Wilbur Wright wrote cautiously to Chanute to say that the published figures of Lilienthal were perhaps not accurate. In the autumn of 1901, to satisfy themselves about the failure of their 1900 and 1901 gliders to lift according to the calculations they had made, and also to check the figures in

the tables published by Lilienthal, the brothers made their remarkable wind tunnel research. From it they obtained data for the construction of their 1902 glider and 1903 aeroplane, data used, indeed, for all their machines up to the death of Wilbur in 1912. In this volume are printed the results of this work, with diagrams of the model aerofoils.

An interesting appendix to this first volume is Octave Chanute's diary of his own gliding experiments in 1896.

Remarkable as were the range and results of their wind tunnel work, one wonders, sometimes, if pride of place should not be given to the Wrights' investigation of the propeller problem, in theory and practice. The propellers they designed were the most efficient of their day. It is unfortunate, in view of the good results that were obtained, that the propellers notes are so difficult to follow. In an appendix a very clear and thorough analysis has been made of the notes, and it is of considerable interest to note that the Wrights in 1902-3 used the system of propeller analysis which Richard von Mises calls the method of a representative blade element, as outlined in his book on the *Theory of Flight* in 1945. In July 1903 Wilbur wrote to Chanute and criticised Drzewiecki's theories in a way that indicated how thoroughly he and his brother had discussed the new and difficult problem which faced them and which had to be solved with reasonable accuracy before they could give any prediction of the possible performance of the aeroplane they were building.

Volume I covers the flights of 1903, 1904 and 1905, when circular flights of over 20 miles were made. The brothers were fully satisfied with the results they had obtained in that last year. At the end of 1904 Wilbur had written to Chanute, " It is a question whether we are not ready to begin considering what we will do with our baby now that we have it."

Volume II covers the period 1906-48. Much of it is concerned with the negotiations with various governments, all of which wanted the Wright machine for themselves and no one else. Here also are the Wright diaries and letters for 1908, that year of flying miracles in the United States and France by the brothers.

This volume, in an Appendix, gives a general survey and much detail of the gliders, aeroplanes and engines constructed by the Wrights and the Wright Company from 1899 to 1915. That latter year saw the last Wright aeroplane with a double vertical rudder and with pusher propellers, and also the first tractor and first machine to use ailerons in place of the wing warping which had been such a feature of all the Wright gliders and aeroplanes for sixteen years.

There is an excellent bibliography, beginning with the entry WILBUR WRIGHT. *Angle of Incidence. The Aeronautical Journal, July* 1901. *Vol.* 5, *pp.* 47-49. It is followed by an editorial note that as far as can be ascertained this article and one published in the *Illustrierte Aeronautische Mitteilungen* the same month on the advantages of the prone position on the lower plane when gliding, are the first papers by the brothers to appear in print.

Apart from the wealth of technical information revealed in the diaries, letters and writings of the brothers, there is much which reveals their characters, their clarity of thinking, high integrity, and their astonishing confidence. The character of Wilbur may perhaps be summed up in an extract from the diary of his father, quoted in these volumes.

" Thursday May 30 1912. This morning at 3.15 Wilbur passed away, aged 45 years 1 month and 14 days. A short life, full of consequences. An unfailing intellect, imperturbable temper, great self-reliance, and as great modesty, seeing the right clearly, pursuing it steadily, he lived and died."

And so, of Orville, who died on January 30 1948.

HISTORY OF STRENGTH OF MATERIALS. *Stephen P. Timoshenko. McGraw-Hill, 1953. 452 pp. Diagrams and Photographs. 71s. 6d. net.*

The advance of material civilisation has been evolutionary. It somewhat surprisingly has no close connection with Man's spasmodic gains in his fundamental knowledge of materials His change in habitat from the cave to the castle or the cottage has been a journey in time of possibly something like 30,000 years. In this not inconsiderable period, however, his mastery of materials, by which is meant his understanding of their chemistry and physics, has been slow indeed.

Until the availability of metal in massive forms, Man, with few exceptions (of which the boat is perhaps the outstanding example, and the suspension bridge a lesser one), has made his structures of materials suitable for taking compressive loads. By the application of purely empirical ideas (some of which were so charmingly put before the Society by Professor Hoff in the 41st Wilbur Wright Memorial Lecture), he has built age-long enduring structures, some of immense size like the Pyramids, some of inspiring dignity like the Parthenon, and some of incomparable beauty like the Taj Mahal. All these things has he done and more also without any appreciable scientific knowledge of the materials he employed—the World has indeed been enduringly enriched by the fruits of empiricism.

What we now all too complacently term our scientific knowledge of materials is, in historic terms, of relatively recent origin. That almost universal genius, Leonardo da Vinci, probably made the first tensile test of a metallic specimen. Getting on for two hundred years later, elasticity was discovered by Hooke. Only a century and a half ago, Thomas Young defined in all too difficult terms the modulus to which his name is so rigidly attached. About a generation later, Albert in Germany, Poncelet in France, and McConnell in England were beginning to glimpse, as through a glass darkly, at what we still see with doubt and dread—fatigue.

Those interested in the history of the strength of materials and in those of the theories of elasticity and of structures can profitably turn for sound information to Professor Timoshenko's book. This is erudite without being repellent to those of little mathematical understanding, but a far less learned man with more literary skill could have told a more lively tale—what the reviewer believes to be an inspiring theme has been treated with the uninspiring yet desirable precision of a time-table. Some no doubt would prefer it so?—P. L. TEED.

A HISTORY OF FLYING. *C. H. Gibbs-Smith. Batsford, London, 1953. 304 pp. Illustrated. 21s. net.*

Any man who writes a book with a title " A History of Flying " with no sort of qualification or sub-title is a brave man. As a member of the Royal Aero Club Mr. Gibbs-Smith must be particularly so, since his appearance there will inevitably provoke challenges to duels for omitting some remote " pioneer."

Nevertheless, this is a readable book as well as an excellent book of reference with a bibliography that bears testimony to its author's painstaking research. Detailed subject, author and date indexes will lighten the task of the fact seeker. The text is written in the readable, almost racy and sometimes colloquial, style that one expects from Mr. Gibbs-Smith.

There must be omissions—a real history of flight is a lifetime's task for which no publisher would spare the paper—and there is a tendency to rush the later years. The author also allows one or two of his prejudices and favouritisms to become a little obvious. No reader, however, will quarrel with such enthusiasms as that shown over, for instance, Chanute, who did so much "backroom" work for the foundations of powered flight.

The system of putting the number of an illustration in brackets after the text to which it refers sometimes has amusing results, as when it is said: "It should also be recorded that Cayley was a devoted husband and the father of ten children (53)." (53) is not, of course, a picture of his ten children but of two designs by him for dirigibles. On page 259, Sir Geoffrey de Havilland is described as having the distinction to be the only aircraft *manufacturer* to be R.D.I. I suspect that he is R.D.I. because of his design of aircraft, in which case B. N. Wallis shares the distinction. This reminds me that I saw no reference to geodetic construction. Now that I have started the sort of criticism that I foretold in my first paragraph, I will go on to say that one drawback of the book is its frequent textual diversion from strict chronological order but this is difficult, I suppose, in dealing with individuals whose work extends over a period of time. It is, however, disconcerting.—F. H. SMITH.

TEST PILOT. *Neville Duke and Alan Mitchell. Allan Wingate, London, 1953. 215 pp. Illustrated. 12s. 6d. net.*

While the vapour trails of the Battle of Britain daily were threading and intersecting in the high skies, a quiet young L.A.C. Pilot U/T was achieving his long cherished ambition by learning to fly a Service Tiger Moth at White Waltham in Berkshire. *Test Pilot* tells his story, but the title is somewhat misleading, for scarcely more than fifty pages are devoted to civilian life and the work which has made Neville Duke's name a household word.

Attracted by the compelling, but simple dust-jacket, which so aptly seems to typify this distinguished pilot's character, the British public, curious to peer deeper into his thoughts and actions, will undoubtedly buy this book in not inconsiderable numbers. But they will find no exciting story, no dramatic disclosures, nor revelation of a man's thoughts in moments of peril or deep happiness. Instead it is a straightforward factual sequence of his flying life, written with cautious restraint and a touch of professional journalism that suggests good reportage of Neville Duke's own words. Yet there is a quality of friendly remoteness about him that emerges even in the shadow pages of a book whose brief chapters give no hint that this is the young man who has captured the hearts and imaginations of millions of his countrymen from farmer's boy to the Prime Minister.—HARALD PENROSE.

THE SPIRIT OF ST. LOUIS. *Charles A. Lindbergh. John Murray. 530 pp. Illustrated. 21s. net.*

Here is an outstanding book—a classic of the air which in due time may rank with the writing of Saint Exupery, for both men have distilled their wisdom of flight into terms of human understanding infused with poetry and the sublime spirit of adventure.

On first glancing at this bulky book of Lindbergh's one wondered a little why he had presumed to resuscitate the story of a long age flight, particularly as he had told it already. True the earlier "We—Pilot and Plane" was perhaps a little naïve, so that the account of this first solo crossing from New York to Paris deserved a better recording, even though the Atlantic had been flown before. Certainly nobody would dream of decrying the courage of the man who made so gruelling, hazardous, and epic a flight—but, all the same, more than a quarter of a century has passed since then, so that one picked up the new book with little more interest than to see what had prompted Lindbergh to write it, and what it revealed of his character. So much for the frailty of a reviewer.

The first part of the book proved more interesting by far than expected, describing the conception of the flight, the difficult search for a suitable machine, and the eventual construction of one in the amazing time of a mere two months. Indeed the fascination of the story mounted as it proceeded, so that when Part II was reached it was begun quite eagerly. Only in retrospect could it be appreciated that the first section was no more than a foil to the remaining two thirds of the book, for it is with this latter part that the flight is unfolded—and what a story it is!

Once again the appearance is deceptive, for the subdivision of the account into scrupulous hourly sections might be thought a tedious method when persisted throughout a journey of thirty-four hours; instead it carries the reader with breathless interest through the grandeur, the loneliness, the perils, and the utter weariness of that flight, recapturing with enchanting skill the world of mingled thought and vision that every pilot knows, yet so rarely can describe. But Lindbergh has done more. At first tentatively, and then with growing clarity, he draws across the picture of cloud, water, fog and sunlight, the portrait of his life, each incident related as though it was a thought contemplated subconsciously as he sat through the long hours in the cramped enclosure of his cabin, waiting for the time to be gathered up and bring land at last to view. It is expressed with a mastery of phrase devoid both of heroics and exaggeration, despite the intensity of personal expression and self-revelation.

For the older generation of pilots who flew in the isolation of their own endeavours, knowing nothing of the ease afforded by modern radio aids, this book will bring back every moment of those old and now nostalgic days. Lindbergh expresses the sentiment of it when he writes: "In developing aviation, in making it a form of commerce, in replacing the wild freedom of danger with the civilised bond of safety, must we give up this miracle of air? Will men fly through the sky in the future without seeing what I have seen, without feeling what I have felt? Is that true of all things we call human progress—do the gods retire as commerce and science advance? . . ." And yet he knows, just as all know who have watched the development of any science from an uneasy art, that the miracle will still be there, the same yet differently expressed, when man essays flights beyond the waters of the earth far into the realms of outer space.—HARALD PENROSE.

COMET HIGHWAY. *Henry Hensser. John Murray, London, 1953. 56 pp. 10s. 6d. net.*

A collection of beautiful photographs, some taken on the ground, some from great heights of places and people and scenes along the routes flown by the Comet, by B.O.A.C.'s Photographic Officer. It includes photographs of the Comet in the air and on the ground, interiors of the flight deck and of the cabin and new glimpses of the world the traveller by Comet may see. A good public relations job for the Comet and for B.O.A.C., a superb example of photography and a pleasant half-hour for the viewer and reader.

BOLDNESS BE MY FRIEND. *Richard Pape. 312 pp. Maps. Elek Books, London, 1953. 16s. net.*

Those who heard this book as a radio serial will know that it is a story of a man's determination to escape. Shot

down in the raid which destroyed the Berlin air defence headquarters, the author is captured in Holland after being sheltered by the Dutch resistance. His next escape attempt, through Poland and in the company of a Pole, is a story of privations and endurance and, finally, pleurisy. He betrayed himself by an anti-Hitler exhibition in a crowded canteen! His third attempt, though almost successful, was defeated by circumstances and he returned to Stalag VIIIB to succumb to brain fever and temporary blindness. Undeterred he made further plans which, this time, resulted in his flying again. Inevitably, all escape stories are different, yet all have two things in common: all bear witness to unbelievable tenacity and determination on the part of those who take part and they all call a spade a spade.

FIFTY YEARS OF FLIGHT. *A Chronicle of the Aviation Industry in America, 1903-1953. Welman A. Shrader. 174 pp. Eaton Manufacturing Company, Cleveland.*

Although to English eyes the exclusively American material in this book may be a little tedious, this bias is explainable, since it does not pretend to be anything *but* American. The Author (who is Director of Publications of the Institute of the Aeronautical Sciences) has done a most painstaking job, and as a chronological record the book will be an invaluable source of reference.

TUMULT IN THE CLOUDS. *Andrew Cunningham. Peter Davies, London, 1953. 206 pp. 10s. 6d. net.*

This is a rather disconcerting book. Although described as fiction, it is so matter-of-fact that it reads more like autobiography. The author was a navigator and the narrator is a navigator (in Beaufighters and Mosquitoes). The author is a schoolmaster and the narrator was a schoolmaster. After reading several of these R.A.F. novels I can find three virtues in "Tumult in the Clouds." There is no pseudo-psychiatry. There is very little woman (and what there is is respectable). The occasional coarseness looks as though it has been put in only because the reading public expects it. On the other hand, there are too many personalities and too much travelogue and the author's passion for the short sentence makes the narrative appear disjointed.

AIRCRAFT YEAR BOOK 1952. *Edited by F. Hamlin and others. Lincoln Press, Washington, 1953. 464 pp. $6.00 net.*

This year book is the official publication of the Aircraft Industries Association of America and is now in its 34th annual edition. To anyone requiring a review of aeronautical progress and achievement during 1952 *in America* it is invaluable. Useful features are illustrated reviews of aircraft in production; engines in production; "biographical briefs" (of doubtful value) and a chronology of U.S. Aviation. It is one of those books that you can keep for years and never realise the odd snippets of information it contains.

AIRCRAFT ENGINES OF THE WORLD, 1953. *Paul H. Wilkinson. Pitman, London, 1953. 320 pp. 50s. net.*

The new edition of this book, the eleventh, again presents the latest information on gas turbine and piston engines from all over the world. The data is given in the standardised page form, with numerous photographs, and is up to date as on 1st May 1953. There is also a tabulation of all types of aircraft and their engines and a short section on aviation fuels and lubricants.

ARCTIC SOLITUDES. *Admiral Lord Mountevans. Lutterworth Press, 1953. 143 pp. 12s. 6d. net.*

The only justification for this book being in the Library is a short chapter at the end on "Conquest of the Pole by Air," but the chapter does serve to show the immense difference that air travel can make to man's progress. The other twelve chapters trace man's attempts to reach the North Pole, starting with the Greeks in about 330 B.C. Chapter 13 tells of the introduction, in 1923, of the air element and on the very day that the reviewer finished reading the book he saw, in the papers, an item reporting a "routine" crossing of the North Pole by a Scandinavian Super-Cloudmaster, carrying 40 troops from Oslo to Tokyo. One doubts if even the Greeks would have had a word for such achievement in 30 years!

BRITISH STANDARDS FOR WORKSHOP PRACTICE. *Edited by J. E. Baty. B.S. Handbook No. 2. 1953 Edition. 623 pp. Diagrams and Tables. B.S.I. 21s. net.*

The first edition of this handbook was published ten years ago and was an attempt to place in the hands of engineering executives, draughtsmen and others, in a concise and handy form, such British Standards as were likely to be needed from day to day. Since then the book has been in constant demand and in this, the third edition, a large portion of the contents has been revised to bring it into line with current standards. The material is arranged under six main headings: Limits and Fits; Screw Threads; Gauges; Bolts, Nuts and Metal Thread Screws; Cutting Tools; Machinery Details; Miscellaneous Data.

Additions to the Library

Baty, J. E. (*General Editor*). BRITISH STANDARDS FOR WORKSHOP PRACTICE. B.S. Handbook No. 2. (3rd edition.) B.S.I. 1953.

Biezeno, C. B. and R. Grammel. TECHNISCHE DYNAMIK. 2 volumes. (2nd edition.) Springer. 1953.

Duke, N. TEST PILOT. Wingate. 1953.

Edwards, H. H. STUDENT AND PRIVATE PILOT'S HANDBOOK. Pitman. 1953.

Green, W. and G. Pollinger. THE OBSERVER'S BOOK OF AIRCRAFT. 2nd edition. Warne. 1953.

Hamlin, F. et al (*Editors*). AIRCRAFT YEAR BOOK 1952. Lincoln. 1953.

Harrison, M. AIRBORNE AT KITTY HAWK. Cassell. 1953.

Howarth, L. (*Editor*). MODERN DEVELOPMENTS IN FLUID DYNAMICS. HIGH SPEED FLOW. Volumes 1 and 2. O.U.P. 1953.

Latimer-Needham, C. H. HEMISPHERICAL BOMBING. Flight Refuelling. 1953.

Morgan, P. (*Editor*). PLASTICS PROGRESS 1953. Iliffe. 1953.

National Manpower Council. A POLICY FOR SCIENTIFIC AND PROFESSIONAL MANPOWER. Columbia University. N.Y. 1953.

Pape, R. BOLDNESS BE MY FRIEND. Elek. 1953.

Reed, H. R. and C. M. Russell. ULTRA HIGH FREQUENCY PROPAGATION. Wiley. 1953.

Shapiro, A. H. THE DYNAMICS AND THERMODYNAMICS OF COMPRESSIBLE FLUID FLOW. Volume 1. Ronald Press. 1953.

Shaw, F. S. AN INTRODUCTION TO RELAXATION METHODS. Dover. 1953.

Shrader, W. A. FIFTY YEARS OF FLIGHT, 1903-53. Eaton Manufacturing Company. 1953.

Sloley, R. W. and W. H. Coulthard. THE AIRCRAFT ENGINEER'S HANDBOOK NO. 4. INSTRUMENTS. Pitman. 1953.

Speller, W. J. C. AIRFRAME STRUCTURE AND CONTROLS, FLYING INSTRUMENTS AND EQUIPMENT. Pitman. 1953.

Titanium Metals Corp. HANDBOOK ON TITANIUM METAL. 7th edition. 1953.

Reports

AERODYNAMICS

Boundary Layer

See also Wings and Aerofoils

Growth of the turbulent wake close behind an aerofoil at incidence. D. A. Spence. A.R.C. Current Paper No. 125. (*May* 1952, *published* 1953.)

Examination of data now available reveals that in the wake: (*i*) velocity profiles on either side of the line of minimum velocity may be derived from the corresponding trailing-edge boundary-layer profiles by change of scale of each co-ordinate; (*ii*) the velocity defect at corresponding points follows a universal recovery law, even close to the trailing edge. An immediate consequence of these two empirical properties is a simple relation for the form parameter at points in the wake in terms of trailing edge values.—(1.1).

*A one-parameter method for the calculation of the temperature profile of laminar incompressible boundary layer flow with a pressure gradient. J. A. Zaat. N.L.L. Holland. Report F.*127. (*March* 1953.)

Based on von Kármán's momentum equation and the integrated heat equation for boundary layers, a new assumption has been made with respect to the temperature profile of the laminar incompressible boundary layer flow. The method has been developed with the aid of the symptotic behaviour of the temperature profiles at the outer edge of the temperature boundary layer and at the same time accounts for as much boundary values at the wall as possible.—(1.1.1 × 1.9.1).

A study of the stability of the incompressible laminar boundary layer on infinite wedges. Neal Tetervin. N.A.C.A. T.N. 2976. (*August* 1953.)

Hartree's numerical solutions of the boundary-layer equations for the flow over infinite wedges are used to confirm a result previously obtained by the use of Schlichting's approximate method for the calculation of the laminar boundary layer. The investigation also leads to the inference that the calculated effects of a change in boundary-layer thickness on the stability and on the local roughness Reynolds number should be essentially unchanged by replacing the Schlichting single-parameter family of velocity profiles by the Hartree family.—(1.1.1).

Compressible Flow

A relaxation treatment of shock waves. L. C. Woods. A.R.C. Current Paper No. 134. (1953.)

Emmons has given a relaxation method of dealing with shock waves when the compressible stream function is the dependent variable. This paper briefly outlines a procedure to adopt when $\log 1/q$ (q=velocity magnitude) is taken as the dependent variable. A method of allowing for the presence of vorticity behind the shock wave is also given.—(1.2.3).

Nouvelles équations approchées pour l'étude des écoulements subsoniques et transsoniques. M. Liger. O.N.E.R.A. France. Publication No. 64. (1953.)—(1.2).

Control Surfaces

Effect of aspect ratio on the low-speed lateral control characteristics of untapered low-aspect-ratio wings equipped with flap and with retractable ailerons. Jack Fischel, Rodger L. Naeseth, John R. Hagerman and William M. O'Hare. N.A.C.A. Rept. 1091. (1952.)

A low-speed wind tunnel investigation was made to determine the lateral control characteristics of a series of untapered low-aspect-ratio wings. Design charts based on experimental results are presented for estimating the flap aileron effectiveness for low-aspect-ratio, untapered, unswept wings.—(1.3.1).

Lift and pitching moment at low speeds of the N.A.C.A. 64*A*010 *airfoil section equipped with various combinations of a leading-edge slat, leading-edge flap, split flap, and double-slotted flap. John A. Kelly and Nora-Lee F. Hayter. N.A.C.A. T.N.* 3007. (*September* 1953.)

Results of a two-dimensional wind tunnel investigation of an N.A.C.A. 64A010 aerofoil equipped with a leading-edge flap, a leading-edge slat, a split flap, and a double-slotted flap are presented. The results include determination of optimum slat positions and effects of varying Reynolds number on the lift and pitching-moment characteristics of the model with the various high-lift devices.—(1.3.4).

Fluid Dynamics

Flow patterns in the wake of an oscillating aerofoil. J. B. Bratt. R. & M. 2773. (*March* 1950, *published* 1953.)

Part I of the report gives an account of experiments made with the National Physical Laboratory smoke generator to obtain smoke patterns in the wake of an aerofoil performing a rolling oscillation in a wind stream. Calculations are given in Part II relating to the smoke patterns produced by a nozzle in uniform motion relative to (*a*) an infinite row of equally spaced two-dimensional discrete vortices of alternate sign and (*b*) an infinite two-dimensional vortex sheet with sinusoidal distribution of strength.—(1.4).

The use of a shallow water channel for quantitative investigation of compressible gas flow. P. F. R. Weijers. A.R.L. Australia. Aerodynamics Note 123. (*May* 1953.)

The theory of the analogy between water flow with a free surface and two-dimensional gas flow is analysed. An attempt is made to establish a simple relation between hydraulic jumps and normal shock waves. It is found that an analogy exists between these phenomena.—(1.4).

Synthèse énergétique de l'auto-propulsion. (*Synthesis of self-propulsion by energy method*) (*English and French*). *M. Roy. O.N.E.R.A. France. Note Technique No.* 14. (1952, *published* 1953.)—(1.4).

Internal Flow

An analysis of the air flow through the nozzle blades of a single stage turbine. I. H. Johnston. A.R.C. Current Paper No. 131. (*February* 1951, *published* 1953.)

The results of detailed traverses made on three of the nozzle assemblies designed for a single stage experimental turbine are presented. The effects of pitch/chord ratio on gas outlet angle and total head loss are recorded and discussed in the light of corresponding work published elsewhere.—(1.5.3).

Tests on an axial compressor with various stator blade staggers. R. A. Jeffs, E. L. Hartley and P. Rooker. A.R.C. Current Paper No. 132. (1953.)

This Memorandum presents the results of a series of low speed tests on six stages of a medium stagger free vortex design of axial compressor blading, in which the stagger of the stator blades was varied over a wide range, while the rotor blade stagger remained at its design figure.—(1.5.2).

Schlieren tests on some conventional turbine cascades. J. A. Dunsby. R. & M. 2728. (*September* 1949, *published* 1953.)

Schlieren tests on a series of conventional turbine cascades have shown that the variations in performance at high speed can be accounted for by shock-wave and boundary-layer interaction. The rise in loss coefficient sometimes encountered at outlet Mach numbers of 0·6 to 0·8 is shown to be due to the formation of a λ-shock series on the upper surface of the blade, the subsequent fall in loss coefficient and increase in deflection as the outlet Mach number rises to unity being caused by the formation of a shock system at outlet, which forces the separated part of the boundary layer back on to the blade surface. It is shown that a λ-shock series may form on a boundary layer which is apparently turbulent.—(1.5.4).

NOTE:—*The figures in parenthesis at the end of each Summary are for office use only.*

Impingement of droplets in 90° elbows with potential flow. Paul T. Hacker, Rinaldo J. Brun and Bemrose Boyd. N.A.C.A. T.N. 2999. (*September* 1953.)

Trajectories were determined for droplets in air flowing through 90° elbows especially designed for two-dimensional potential motion with low pressure losses. The elbows produced by the complex potential function selected are suitable for use in aircraft air-intake ducts. The droplet impingement data derived from the trajectories are presented, along with equations in such a manner that the collection efficiency, the area, the rate, and the distribution of droplet impingement can be determined for any elbow defined by any pair of streamlines within a portion of the flow field established by the complex potential function.—(1.5.1).

Theoretical performance characteristics of sharp-lip inlets at subsonic speeds. Evan A. Fradenburgh and DeMarquis D. Wyatt. N.A.C.A. T.N. 3004. (*September* 1953.)

A method is presented for the estimation of the subsonic-flight-speed characteristics of sharp-lip inlets applicable to supersonic aircraft. The analysis, based on a simple momentum balance consideration, permits the computation of inlet pressure recovery-mass-flow relations and additive-drag coefficients for forward velocities from zero to the speed of sound.—(1.5.1).

Performance Estimation

*Energy approach to the general aircraft performance problem. E. S. Rutowski. Douglas Report No. SM-*14875. (*July* 1953.)

The general aircraft performance problem is considered from the point of view of the balance that must exist between the potential and kinetic energy change of the aircraft, the energy dissipated against the drag, and the energy derived from the fuel.—(1.7).

An analysis of the power-off landing maneuver in terms of the capabilities of the pilot and the aerodynamic characteristics of the airplane. Albert E. von Doenhoff and George W. Jones, Jr. N.A.C.A. T.N. 2967. (*August* 1953.)

A theoretical analysis of the power-off landing manoeuvre is presented in which an attempt is made to consider both the aerodynamic characteristics of the aeroplane and the human capabilities of the pilot. Certain factors are derived which allow for the variations in pilot judgment in a manner which is directly connected to pilot capabilities. An analysis including these factors is set up by means of which the minimum length of landing field required for landing an aeroplane safely could be found.—(1.7).

Stability and Control

Estimation of forces and moments due to rolling for several slender-tail configurations at supersonic speeds. Percy J. Bobbitt and Frank S. Malvestuto, Jr. N.A.C.A. T.N. 2955. (*July* 1953.)

A method, based on conformal-transformation techniques, for solving two-dimensional boundary value problems has been used to evaluate the velocity potentials, span loadings, pressure distributions, and associated stability derivatives for several slender-tail arrangements performing a steady rolling motion.—(1.8.2).

Application of several methods for determining transfer functions and frequency response of aircraft from flight data. John M. Eggleston and Charles W. Mathews. N.A.C.A. T.N. 2997. (*September* 1953.)

A study is presented of several methods for determining the transfer functions and frequency response of aircraft from flight tests. Results obtained from experience in the use of these methods are compared as to time required for application, comparative accuracy, and means for facilitating their use. The studies cover three categories of methods: sinusoidal response, Fourier analysis of transients, and curve-fitting analysis of transients. Three general types of aircraft are used to illustrate the application of these methods.—(1.8.2).

Thermo-aerodynamics

Aerodynamic heating on yawed infinite wings and on bodies of arbitrary shape. H. Schuh. K.T.H. Sweden. Aero T.N. 35. (*July* 1953.)

It is shown that exact solutions can be obtained for the thermal boundary layer equation in laminar flow on yawed wedges with zero heat transfer. Numerical values for air yield a recovery factor almost independent of pressure gradient and very nearly equal to that of an unyawed flat plate at zero incidence. Results can be applied directly to yawed cylinders (infinite wings) of arbitrary cross-section. General considerations suggest the application of these results also on bodies of arbitrary shape, for instance on swept and delta wings, provided that no flow separation occurs.—(1.9.1).

Wings and Aerofoils

Note on the lift slope, and some other properties, of delta and swept-back wings. E. F. Relf. A.R.C. Current Paper No. 127. (*June* 1952, *published* 1953.)—(1.10.2.2).

Method for the determination of the pressure distribution over a finite thin wing at a steady low speed. G. J. Hancock. A.R.C. Current Paper 128. (*September* 1952, *published* 1953.)

For any given pressure distribution across a finite thin wing at low speed the wing surface can be obtained by direct double integration. Therefore the pressure distribution across a given wing surface may be obtained by the superposition of a number of solutions in which the wing surface is known for a prescribed pressure distribution. The method has been applied for the determination of the pressure distribution across a thin uncambered delta wing.—(1.10.1.2).

Velocity distribution on untapered sheared and swept-back wings of small thickness and finite aspect ratio at zero incidence. S. Neumark. R. & M. 2717. (*March* 1949, *published* 1953.)

This report is a continuation of an earlier one and puts forward several new solutions of the problems of velocity distribution on finite or semi-infinite untapered wings, at zero incidence. The solutions are based on the first order method of sources and sinks, which is shown to be sufficiently accurate to deal with problems involving tips or kinks. The fundamental case considered is that of a semi-infinite sheared wing, and the theory is built up to embrace finite sheared and swept-back wings, straight wings being dealt with as special cases. Complete detailed solutions are given for wings with biconvex parabolic profile, and the problems involving arbitrary profiles are investigated in a more general way.—(1.10.1.2).

The evaluation of downwash at large spanwise distances from a vortex lattice. H. C. Garner. R. & M. 2808. (*December* 1950, *published* 1953.)

An improved numerical method is explained of evaluating the contributions to the downwash at moderate or large spanwise distances from a vortex lattice. By allowing freedom of choice of the chordwise positions of the discrete vortices of the lattice, it is possible to select three definite chordwise positions and strengths of vortices at each of these positions dependent on the chordwise pressure distribution, so as to determine the downwash with good accuracy for three particular pressure distributions. The corresponding chordwise loading factors have also been evaluated for deflected flaps.—(1.10.1.2).

The two-dimensional subsonic flow of an inviscid fluid about an aerofoil of arbitrary shape. L. C. Woods. R. & M. No. 2811. (*November* 1950, *published* 1953.)

Exact methods are described and applied for calculating the incompressible flow about thick aerofoils of general shape in a free stream, and about symmetrical aerofoils between channel walls. One of these methods is extended to an approximate treatment of subsonic compressible flow by making use of von Kármán's transformation.—(1.10.1.1).

Étude des écoulements transsoniques autour des profils lenticulaires, a incidence nulle. R. Michel, F. Marchaud et J. Le Gallo. O.N.E.R.A., France. Publication No. 65. (1953.)—(1.10.2.1.)

The influence of camber and geometrical twist on low-aspect-ratio wings of finite thickness in subsonic, transonic and supersonic flow. F. Keune. K.T.H. Sweden. Aero T.N. 29. (*June* 1953.)

The influence of camber on the flow past a wing of finite thickness and low aspect ratio, particularly its effect on the coefficients of lift and moments, the angle of incidence and the pitching moments both at zero lift, are given. In close connection with a previously published work, the influence of camber on the flow over the surface of a wing with thickness and camber at an arbitrary angle of incidence are investigated.—(1.10.1.2).

The rest of the Reports received by the Library this month will be published in the January JOURNAL.

The Journal of the Royal Aeronautical Society

WITH WHICH IS INCORPORATED THE INSTITUTION OF AERONAUTICAL ENGINEERS

INDEX TO VOL LVII January - December 1953

ACCELEROMETERS
See Gusts.
Reduction of Flight Test Data from Linear Accelerometers (T.N.), Andrew Mokrzycki, p. 415 (June).

ACOUSTICS
Acoustic Screening by an Experimental Running Up Pen, J. D. Hayhurst, p. 3 (Jan.).
Research on Aerodynamic Noise from Jets and Associated Problems, E. J. Richards, p. 318 (May).
Some Aspects of Noise from Supersonic Aircraft, G. M. Lilley, R. Westley, A. H. Yates and J. R. Busing, p. 396 (June).
The Noise from Aircraft Travelling with Velocities Greater than that of Sound (T.N.), A. G. Walters, p. 719 (Nov.).

AERODYNAMICS
An Experimental Study of a Symmetrical Aerofoil with a Rear Section Slot and a Retractable Flap, D. M. Heughan, p. 627 (Oct.).
Fuselage Lift Distribution for a Swept-Back Wing Aircraft (T.N.), W. Taylor, p. 464 (July).
Normal Shock-Wave Phenomena in a Convergent-Divergent Nozzle, B. W. Martin, p. 455 (July).
Note on the Application of Busemann's Formula to a Simple Two-Dimensional Curved Aerofoil Section (T.N.), J. A. Dunsby, p. 600 (Sept.).
Resolution of Velocity for the Swept-Back Wing at Incidence (T.N.), C. H. McKoen, p. 177 (March).
Some Measurements of Leading Edge Separation Bubbles on a 10 per cent. thick Symmetrical Aerofoil (T.N.), J. Black and R. D. Hunt, p. 819 (Dec.).
The Potential and Field of Flow (Induced Velocity) of a Plane Vortex (T.N.), J. Lockwood Taylor, p. 179 (March).
Types of Flow on Swept Wings with Special Reference to Free Boundaries and Vortex Sheets, D. Küchemann, p. 683 (Nov.).

AILERON REVERSAL
A Note on the Problem of Aileron Reversal at Transonic Speeds (T.N.), B. A. Hunn, p. 237 (April).

AIR TRAFFIC CONTROL
See V. A. M. Hunt.

AIR TRANSPORT
Air Traffic Control Today and Tomorrow, V. A. M. Hunt, p. 301 (May).
Civil Jet Operations, A. M. A. Majendie, p. 539 (Sept.).
Estimation of the Fatigue Life of a Transport Aircraft, P. B. Walker, p. 613 (Oct.).
Making Commercial Aircraft Pay—Sixth Louis Bleriot Lecture, Guy du Merle, p. 429 (July).
Optimum Conditions for the Operation of Airline Aircraft (T.N.), Alan H. Stratford, p. 524 (Aug.), p. 824 (Dec.), J. M. Stephenson, p. 823 (Dec.).
Some Problems in the Development of Air Transport in West Africa—Ninth British Commonwealth and Empire Lecture, Sir Hubert Walker, p. 477 (Aug.).

ANGLO-AMERICAN AERONAUTICAL CONFERENCE
P. 709 (Nov.).

ANNAND, W. J. D.
Resistance to Air Flow of Wire Gauzes, p. 141 (March).

AWARDS AND MEDALS
See Royal Aeronautical Society.

ANNUAL REPORT
See Royal Aeronautical Society.

BARRETT, ANTHONY J.
Bending of Some Common Beam Sections into the Plastic Range (T.N.), p. 110 (Feb.).
Unsymmetrical Bending and Bending Combined with Axial Loading of a Beam of Rectangular Cross Section into the Plastic Range, p. 503 (Aug.).

BENHAM, P. P.
Bending Moments in Fuselage Frames Obtained by the Photoelastic Method, p. 667 (Nov.).

BISHOP, R. E. D.
The Normal Functions of Beam Vibration in Series Solutions of Static Problems (T.N.), p. 527 (Aug.).

BLACK, J. AND R. D. HUNT
Some Measurements of Leading Edge Separation Bubbles on a 10 per cent. thick Symmetrical Aerofoil (T.N.), p. 819 (Dec.).

BLERIOT, LOUIS—SIXTH LECTURE
Making Commercial Aircraft Pay, G. du Merle, p. 429 (July).

BOSTON, D. C.
Deformations and Stresses in Symmetrically Loaded and Circular Plates of Varying Thickness, p. 449 (July).

BRITISH COMMONWEALTH AND EMPIRE LECTURE—NINTH
Some Problems in the Development of Air Transport in West Africa, Sir Hubert Walker, p. 477 (Aug.).

BUSING, J. R., G. M. LILLEY, R. WESTLEY AND A. H. YATES
Some Aspects of Noise from Supersonic Aircraft, p. 396 (June).

CARPETS
An Application of Carpet and Lattice Plotting (T.N.), R. Tatham, p. 107 (Feb.).

CLOUSTON, A. E.
Training of Test Pilots, p. 39 (Jan.).

COMPRESSORS
Compressor Design (T.N.), R. G. Taylor, p. 463 (July).
Measurement of the Profile Drag of Compressor and Turbine Cascades and the Effect of Wakes in Exciting Vibration (T.N.), J. M. Stephenson, p. 722 (Nov.).
On the Stability of a Flow of Gas out of a Compressor (T.N.), J. M. Stephenson, p. 345 (May).
The Elimination of Wall Effects in Axial Flow Compressor Stages (T.N.), J. M. Stephenson, p. 241 (April).

CORRESPONDENCE
Stressing of Circular Frames, K. J. Dallison, p. 268 (April), W. J. Goodey, p. 267 (April), B. Saravanos, p. 267 (April).
Oscillatory Occurrences in Ball Bearings, M. S. Frenkel, p. 531 (Aug.), R. J. Millson, p. 530 (Aug.).
The Scope and Limitations of the Photoelastic Method of Stress Analysis—A Correction, H. T. Jessop, p. 267 (April).
H. O. Mance, p. 54 (Jan.).
The Journal, J. Laurence Pritchard, p. 52 (Jan.).
Temperature Control, E. W. Still and J. A. C. Williams, p. 268 (April).

COUNCIL REPORT
See Royal Aeronautical Society.

COX, H. L.
Fatigue, p. 559 (Sept.).

CUNDALL, H. B. AND W. TYE
Lifing of Aircraft Equipment and Instruments, p. 391 (June).
See also Technical Notes, pp. 597-9 (Sept.).

DALLISON, K. J.
Stress Analysis of Circular Frames in a Non-Tapering Fuselage, p. 151 (Mar.). Correspondence, pp. 267-8 (Apr.).

DAVIES, C. B.
Developing Aviation Fuels and Lubricants, p. 700 (Nov.).

DAWSON, L. G.
The Fluid Mechanics of Detonation Waves, p. 618 (Oct.).

DEFECT RATE
See Lifing.

DESIGN AND CONSTRUCTION
See also Inspection.
Integral Construction—Its Application to Aircraft Design and its Effect on Production Methods, E. D. Keen, p. 215 (April). Discussion, p. 461 (July).
New Materials and Methods for Aircraft Construction, H. J. Pollard, p. 277 (May).
Structure Weight, J. Taylor, p. 646 (Oct.).

D.H. COMET
See A. M. A. Majendie.

DICKINSON, C. J. AND H. R. HADLEY
Pressure Tests on Flat Aluminium Alloy Panels (T.N.), p. 46 (Jan.).

DIMENSIONS
See Inspection.

DIPLOCK, B. R., D. L. LOFTS AND R. A. GRIMSTON
Liquid Propellant Rocket Motors, p. 19 (Jan.).

DU MERLE, GUY
Making Commercial Aircraft Pay—Sixth Louis Bleriot Lecture, p. 429 (July).

DUNCAN, W. J.
The Flexural Centre or Centre of Shear (T.N.), p. 594 (Sept.).

DUNSBY, J. A.
Note on the Application of Busemann's Formula to a Simple Two-Dimensional Curved Aerofoil Section (T.N.), p. 600 (Sept.).

EGGWERTZ, S. AND A. NORR
Influence of Edge Conditions and Initial Deflections of a Plate under Normal Pressure (T.N.), p. 343 (May).

ENGINES
See also Compressors, Fatigue and Rockets.
Measurement of the Profile Drag of Compressor and Turbine Cascades and the Effect of Wakes in Exciting Vibration (T.N.), J. M. Stephenson, p. 722 (Nov.).
Temperature Control of Jet-Engined Aircraft, E. W. Still, p. 89 (Feb.).

FATIGUE
Design Criterion for Fatigue of Wings, P. B. Walker, p. 12 (Jan.).
Estimation of the Fatigue Life of a Transport Aircraft, P. B. Walker, p. 613 (Oct.).
Fatigue—A Discussion, p. 559 (Sept.); Fatigue, H. L. Cox, p. 559; From the Metallurgist's Viewpoint, E. R. Gadd, p. 565; In Engine Design, F. M. Owner, p. 580; In Aircraft Design, B. E. Stephenson, p. 588; Summary of Discussions, W. Tye, p. 589.
Fatigue Properties of Z-Section Test Pieces Completely Machined from an Aluminium Alloy Extrusion Conforming to D.T.D.364B (T.N.), G. Forrest, K. W. Gunn, A. R. Woodward, p. 103 (Feb.).

FEDDEN, SIR A. H. ROY
Rex Pierson—An Appreciation and the Lessons of his Work, p. 63 (Feb.).

FINK, P. T.
A Simple Rolling Method for I_p (T.N.), p. 419 (June).

FLUTTER
A Method of Calculating Space Free Resonance Modes of an Aircraft (T.N.), B. A. Hunn, p. 420 (June).
Design of a Simple Electronic Flutter Simulator, F. Smith and W. D. T. Hicks, p. 29 (Jan.).

FLIGHT REFUELLING
The Development of "Probe and Drogue" Refuelling, P. S. MacGregor, p. 510 (Aug.).

FORREST, G., K. W. GUNN AND A. R. WOODWARD
Fatigue Properties of Z-Section Test Pieces Completely Machined from an Aluminium Alloy Extrusion conforming to D.T.D.364B (T.N.), p. 103 (Feb.).

FUELS AND LUBRICANTS
Developing Aviation Fuels and Lubricants, C. B. Davies, p. 700 (Nov.).

GADD, E. R.
Fatigue from the Metallurgist's Viewpoint, p. 565 (Sept.).

GARDEN PARTY—1953
P. 520 (Aug.).

GAUZES
Resistance to Air Flow of Wire Gauzes, W. J. D. Annand, p. 141 (March).

GOULD, R. W. F.
Differential Inductance Telemeter Equipment for Force and Moment Measurements (T.N.), p. 416 (June).

GREENWOOD, S. W.
Definition of Specific Impulse (T.N.), p. 819 (Dec.).

GRIMSTON, R. A., B. R. DIPLOCK AND D. L. LOFTS
Liquid Propellant Rocket Motors, p. 19 (Jan.).

GUNN, K. W., G. FORREST AND A. R. WOODWARD
Fatigue Properties of Z-Section Test Pieces Completely Machined from an Aluminium Alloy Extrusion Conforming to D.T.D.364B, (T.N.), p. 103 (Feb.).

GUSTS
See also Fatigue.
Measurement of Gust Loads in Aircraft, J. Taylor, p. 78 (Feb.).

HADLEY, H. R. AND C. J. DICKINSON
Pressure Tests on Flat Aluminium Alloy Panels (T.N.), p. 47 (Jan.).

HAYHURST, J. D.
Acoustics Screening by an Experimental Running Up Pen, p. 3 (Jan.).

HEFFERNAN, K. J. AND J. WARNER
The Use of Radar to Measure the True Air Speed of an Aircraft (T.N.), p. 653 (Oct.).

HELICOPTERS
An Introduction to the Helicopter, J. D. Sibley, p. 228 (April).

HEUGHAN, D. M.
An Experimental Study of a Symmetrical Aerofoil with a Rear Suction Slot and a Retractable Flap, p. 627 (Oct.).

HICKS, W. D. T. AND F. SMITH
Design of a Simple Electronic Flutter Simulator, p. 29 (Jan.).

HISTORICAL
Experiments with Flat Planes, J. L. Pritchard, p. 147 (Mar.).
The Hodgson-Cuthbert Collection, J. L. Pritchard, p. 351 (June).
The Wright Brothers and the Royal Aeronautical Society, J. L. Pritchard, p. 739 (Dec.).

HODGSON-CUTHBERT COLLECTION, THE
J. Laurence Pritchard, p. 351 (June).

HODSON, B. A.
A Method of Calculating Stresses in a Non-Uniformly Thick Disc Subjected to Asymmetric Loads Adapted to a Tabular Computation (T.N.), p. 658 (Oct.).

HOWARD, H. B.
Tube of Least Weight for Given Torsional Stiffness (T.N.), p. 45 (Jan.).

HUNN, B. A.
A Method of Calculating Space Free Resonance Modes of an Aircraft (T.N.), p. 420 (June).
A Note on the Problem of Aileron Reversal at Transonic Speeds (T.N.), p. 237 (April).

HUNT, R. D. AND J. BLACK
Some Measurements of Leading Edge Separation Bubbles on a 10 per cent. thick Symmetrical Aerofoil (T.N.), p. 819 (Dec.).

HUNT, V. A. M.
Air Traffic Control Today and Tomorrow, p. 301 (May).

INSPECTION
Dimensions Required for Inspection (T.N.), G. A. Saywell, p. 463 (July), A. C. Parks, p. 725 (Nov.).

INSTRUMENTS
See also Accelerometers, Strain Gauges and Wind Tunnel.
Differential Inductance Telemeter Equipment for Force and Moment Measurements (T.N.), R. W. F. Gould, p. 416 (June).

INTEGRAL CONSTRUCTION
See Design and Construction.

JACOBS, JOHN A.
The Centre of Shear of Aerofoil Sections (T.N.), p. 235 (April).

JESSOP, H. T.
The Scope and Limitations of the Photoelastic Method of Stress Analysis, p. 125 (March). Correction, p. 267 (April).

KEEN, E. D.
Integral Construction—Its Application to Aircraft Design and its Effect on Production Methods, p. 215 (April). Discussion, p. 461 (July).

KRZYWOBLOCKI, M. Z. V.
Stress Analysis of Circular Frames (T.N.), p. 600 (Sept.).

KUCHEMANN, D.
Types of Flow on Swept Wings with Special Reference to Free Boundaries and Vortex Sheets, p. 683 (Nov.).

LEAVY, L. E. AND C. G. SAUNDERS
A Modern Wind Tunnel Balance, p. 491 (Aug.).

LECTURE SPEAKERS
See Royal Aeronautical Society.

LIFING
Lifing of Aircraft Equipment and Instruments, W. Tye and H. B. Cundall, p. 391 (June); Technical Note, H. L. Stevens, p. 597 (Sept.), W. Tye, p. 599 (Sept.).

LILLEY, G. M., R. WESTLEY, A. H. YATES AND J. R. BUSING
Some Aspects of Noise from Supersonic Aircraft, p. 396 (June).

LOFTS, D. L., B. R. DIPLOCK AND R. A. GRIMSTON
Liquid Propellant Rocket Motors, p. 19 (Jan.).

MACGREGOR, P. S.
Development of "Probe and Drogue" Refuelling, p. 510 (Aug.).

MAJENDIE, A. M. A.
Civil Jet Operations, p. 539 (Sept.).

MARTIN, B. W.
Normal Shock-Wave Phenomena in a Convergent-Divergent Nozzle, p. 455 (July).

MASEFIELD, P. G.
Foreword (to new size Journal), p. 1 (Jan.).

MATERIALS
See also Fatigue.
Fatigue Properties of Z-Section Test Pieces Completely Machined from an Aluminium Alloy Extrusion Conforming to D.T.D.364B. (T.N.), G. Forrest, K. W. Gunn, A. R. Woodward, p. 103 (Feb.).
New Materials and Methods for Aircraft Construction, H. J. Pollard, p. 277 (May).
Titanium—A Survey, P. L. Teed, p. 189 (April).

McKOEN, C. H.
Resolution of Velocity for the Swept-Back Wing at Incidence (T.N.), p. 177 (March).

MOKRZYCKI, ANDREW
Reduction of Flight Test Data from Linear Accelerometers (T.N.), p. 415 (June).

NAVIGATION
The Coriolis Effect (T.N.), Paul E. Wylie, p. 655 (Oct.).

NEW ZEALAND DIVISION
Fourth Annual Report, p. 264.

NOISE
See Acoustics.

NORR, A. AND S. EGGWERTZ
Influence of Edge Conditions and Initial Deflections of a Plate under Normal Pressure (T.N.), p. 343 (May).

OAKS, J. K.
Stresses and Deflection in a Flat Plate with Clamped Edges under Normal Pressure (T.N.), p. 244 (April). Correction, p. 422 (June).

OWNER, F. M.
Fatigue in Engine Design, p. 580 (Sept.).

PARKS, ALBERT C.
Dimensions Required for Inspection (T.N.), p. 725 (Nov.).

PERFORMANCE
See also A. M. A. Majendie.
Minimum Comfortable Cruising Speed (T.N.), C. F. Toms, p. 180 (March).
Reduction of Flight Test Data from Linear Accelerometers (T.N.), Andrew Mokrzycki, p. 415 (June).
Some Aspects of High Performance Jet Aircraft, W. A. Waterton, p. 375 (June).
The Use of Radar to Measure the True Air Speed of an Aircraft (T.N.), J. Warner and K. J. Heffernan, p. 653 (Oct.).

PHOTOELASTICITY
Bending Moments in Fuselage Frames Obtained by the Photoelastic Method, P. P. Benham, p. 667 (Nov.).
The Scope and Limitations of the Photoelastic Method of Stress Analysis, H. T. Jessop, p. 125 (March). Correction, p. 267 (April).

PIERSON, REX—FIRST MEMORIAL LECTURE
Sir A. H. Roy Fedden, p. 63 (Feb.).

PILOTING
Some Aspects of High Performance Jet Aircraft. W. A. Waterton, p. 375 (June).
Training of Test Pilots. A. E. Clouston, p. 39 (Jan.).

PLANES
Experiments with Flat Planes. J. L. Pritchard, p. 147 (Mar.).

POLLARD, H. J.
New Materials and Methods for Aircraft Construction, p. 277 (May).

PRANDTL, LUDWIG
E. F. Relf, p. LV (Oct.).

PRITCHARD, J. LAURENCE
Experiments with Flat Planes, p. 147 (March).
The Hodgson-Cuthbert Collection, p. 351 (June).
The Wright Brothers and The Royal Aeronautical Society, p. 739 (Dec.).

PRODUCTION
See Design and Construction.

RADAR
See J. Warner and K. J. Heffernan.

RELF, E. F.
Ludwig Prandtl, p. LV (Oct.).

REVIEWS
Across the Parallel. George Odgers, p. 662 (Oct.).
Across the Space Frontier, edited by Cornelius Ryan, p. 116 (Feb.).
Advanced Strength of Materials. J. P. Den Hartog, p. 116 (Feb.).
Aerodynamics of Propulsion. D. Küchemann and J. Weber, p. 732 (Nov.).
Aeronautical Engineering. Vol. II. R. Tatham, p. 732 (Nov.).
Aeronautics at the Mid-Century. Jerome C. Hunsaker, p. 269 (April).
Air Pilot Training. Bert A. Sheilds, p. 271 (April).
Air Transport in India (Growth and Problems). M. R. Dhekney, p. 733 (Nov.).
Air War and Emotional Stress. Irving L. Janis, p. 56 (Jan.).
Aircraft Commander in Commercial Air Transportation, The. Dr. M. S. Kamminga, p. 662 (Oct.).
Aircraft Engines of the World, 1953. P. H. Wilkinson, p. 828 (Dec.).
Aircraft Instrument Design. W. H. Coulthard, p. 184 (March).
Aircraft Propulsion. Theory and Performance. A. W. Morley, p. 604 (Sept.).
Aircraft Structural Mechanics. F. R. Steinbacher, p. 271 (April).
Aircraft Year Book 1952, p. 828 (Dec.).
Analytical Mechanics for Engineers. F. B. Seely and Newton E. Ensign, p. 269 (April).
Arctic Solitudes. Admiral Lord Mountevans, p. 828 (Dec.).
Aviation Medicine, p. 347 (May).
Boldness Be My Friend. R. Pape, p. 827 (Dec.).
Brackles. Memoirs of a Pioneer of Civil Aviation. Frida H. Brackley, p. 471 (July).
British Standards for Workshop Practice. Ed. by J. E. Baty, p. 828 (Dec.).
British War Production. M. M. Postan, p. 606 (Sept.).
Buckling Strength of Metal Structures. Friedrich Bleich, p. 57 (Jan.).
Climate and the British Scene. G. Manley, p. 118 (Feb.).
Comet Highway. H. Hensser, p. 827 (Dec.).
D.C. Power Systems for Aircraft. R. H. Kaufmann and H. J. Finison, p. 58 (Jan.).
Designing by Photoelasticity. R. B. Heywood, p. 472 (July).
Dictionary of Fire Technology, p. 347 (May).
Die Gasturbine. J. Kruschik, p. 608 (Sept.).
Direct Current Machines for Control Systems. A. Tustin, p. 661 (Oct.).
Elasticity in Engineering. E. E. Sechler, p. 473 (July).
Electric Resistance Heating, p. 663 (Oct.).
Elements of Propeller and Helicopter Aerodynamics. D. O. Dommasch, p. 473 (July).
Elements of Wave Mechanics. N. F. Mott, p. 118 (Feb.).
Essentials of Fluid Dynamics, The. L. Prandtl, p. 56 (Jan.).
Essentials of Microwaves. R. B. Muchmore, p. 347 (May).
Fatigue of Metals. R. Cazaud, p. 606 (Sept.).
Fifty Years of Flight. W. A. Shrader, p. 828 (Dec.).
Flames, Their Structure, Radiation and Temperature. A. G. Gaydon and H. G. Wolfhard, p. 661 (Oct.).
Flying Omnibus, The, edited Paul Jensen, p. 663 (Oct.).
Flying Saucers. Donald H. Menzel, p. 606 (Sept.).
Fuels and Combustion. M. L. Smith and K. W. Stinson, p. 533 (Aug.).
Grunlagen der Aeromechanik und Flugmechanik. Arthur Pröll, p. 730 (Nov.).
Handbook of Statistical Methods in Meteorology. C. E. R. Brooks and N. Carruthers, p. 604 (Sept.).
Handbook of Supersonic Aerodynamics, p. 117 (Feb.).
Hazardous Industries, gdited A. S. Minton and W. Thomas, p. 663 (Oct.).
Heat Transfer Phenomena. R. C. L. Bosworth, p. 729 (Nov.).
High-Speed Internal Combustion Engine, The. Sir Harry R. Ricardo, p. 471 (July).
High-Speed Photography. George A. Jones, p. 270 (April).
History of Flying. A. C. H. Gibbs-Smith, p. 826 (Dec.).
History of Strength of Materials. S. P. Timoshenko, p. 826 (Dec.).
How Planes Fly. S. E. Veale and "Wren," p. 663 (Oct.).
Human Factors in Air Transportation. Ross D. McFarland, p. 729 (Nov.).
I Flew for the Fuhrer. Heinz Knoke, p. 733 (Nov.).
Instrument Engineering. Vol. I. Draper, McKay and Lees, p. 468 (July).
Jane's All the World's Aircraft, 1952-53, edited by Leonard Bridgman, p. 471 (July).
Lighting in Industry, p. 269 (April).
Lubricants and Lubrication. Vol. II, p. 661 (Oct.).
Materials Handling in Industry, p. 55 (Jan.).
Molecular Theory of Fluids. H. S. Green, p. 731 (Nov.).
Moteurs a Réaction. G. Lavoisier, p. 608 (Sept.).
Newnes Engineer's Reference Book, edited by F. J. Camm, p. 272 (April).
Numerical Analysis. D. R. Hartree, p. 270 (April).
Observer's Handbook, p. 118 (Feb.).
On Being a Bird. Philip Wills, p. 533 (Aug.).
Papers of Wilbur and Orville Wright. Two Vols., Edited by M. W. McFarland, p. 825 (Dec.).
Physical Aspects of Air Photography. G. C. Brock, p. 119 (Feb.).
Physical Similarity and Dimensional Analysis. W. J. Duncan, p. 424 (June).
Power Plants for Aircraft. Joseph Liston, p. 473 (July).
Presentation of Numerical Values. B.S.I., p. 663 (Oct.).
Principles of Aerodynamics. D. O. Dommasch, p. 469 (July).
Principles of Radar. J. F. Rientjes and G. T. Coates, p. 607 (Sept.).
Proceedings of the General Discussion on Heat Transfer, 1951. Institution of Mechanical Engineers, p. 423 (June).
Proceedings of the Society for Experimental Stress Analysis, Vol. X, No. 1, edited by C. V. Mahlmann and W. M. Murray, p. 424 (June).
Proceedings of the Society for Experimental Stress Analysis, Vol. X, No. 2, edited by C. V. Mahlmann and W. M. Murray, p. 731 (Nov.).
Rocket Propulsion—With an Introduction to the Idea of Interplanatary Travel. Eric Burgess, p. 56 (Jan.).
Science of Petroleum, Vol. V, Part II, joint editors B. T. Brooks and A. E. Dunstan, p. 730 (Nov.).

Sea Shall Not Have Them, The, John Harris, p. 663 (Oct.).
Selection of Tables for Use in Calculations of Compressible Airflow, A, p. 57 (Jan.).
Servomechanism Analysis, G. J. Thaler and R. G. Brown, p. 604 (Sept.).
Solution of Problems in Strength of Materials, S. A. Urry, p. 605 (Sept.).
Sound Barrier, N. Duke and E. Lanchbery, p. 729 (Nov.).
Space Medicine, edited by John P. Marbarger, p. 733 (Nov.).
Spirit of St. Louis, C. A. Lindbergh, p. 827 (Dec.).
Statistical Quality Control, Eugene L. Grant, p. 470 (July).
Strength and Testing of Materials, Parts 1 and 2, p. 468 (July).
Structural Principles and Data, Handbook of Aeronautics, No. 1, p. 183 (March).
Structure of Metals, C. S. Barrett, p. 183 (March).
Studies in Elastic Structures, A. J. S. Pippard, p. 117 (Feb.).
Superconductivity, D. Shoenberg, p. 347 (May).
Teach Yourself to Fly, Nigel Tangye, p. 271 (April).
Test Pilot, Neville Duke, p. 827 (Dec.).
Text Book of Photogrammetry, Dr. M. Zeller, p. 57 (Jan.).
Theory of Elasticity and Plasticity, H. M. Westergaard, p. 605 (Sept.).
Theory of Homogeneous Turbulence, The, G. K. Batchelor, p. 533 (Aug.).
Thermal Diffusion of Gases, K. E. Grew and T. L. Ibbs, p. 474 (July).
Transport by Air, Thomas Insull, p. 474 (July).
Tumult in the Clouds, A. Cunningham, p. 828 (Dec.).
Two Decades of Helicopter Design, p. 663 (Oct.).
Weight-Strength Analysis of Aircraft Structures, F. R. Shanley, p. 423 (June).
Welding Practice, Vols. 2 and 3, edited by E. Fuchs and H. Bradley, p. 469 (July).
Wind Tunnel Technique, Pankhurst and Holder, p. 55 (Jan.).
Wonder Book of Aircraft, The, p. 270 (April).
World Airline Record, 1952 edition, Roy R. Roadcap and Associates, p. 272 (April). *See also* p. 534 (Aug.).
World's Oilfields, The, Vol. VI, Part 1, edited by V. C. Illing, p. 470 (July).
Writing the Technical Report, J. R. Nelson, p. 470 (July).

RICHARDS, E. J.
Research on Aerodynamic Noise from Jets and Associated Problems, p. 318 (May).

R. K. PIERSON MEMORIAL LECTURE
Rex Pierson—An Appreciation and the Lessons of his Work, Sir A. H. Roy Fedden, p. 63 (Feb.).

ROCKETS
Liquid Propellant Rocket Motors, B. R. Diplock, D. L. Lofts, R. A. Grimston, p. 19 (Jan.).
Definition of Specific Impulse (T.N.), S. W. Greenwood, p. 819 (Dec.).

ROYAL AERONAUTICAL SOCIETY
A Message from the President, G. H. Dowty, p. III (Jan.).
Acknowledgments, pp. XIV (Feb.), XVII (March, XXIV (April), XXXII (May), XXXVI (June), XL (July), XLVI (Aug.), LVIII (Oct.), LXIV (Nov.), — (Dec.).
Additions to the Library, pp. 58, 119, 184, 272, 347, 424, 474, 534, 608, 663, 733, 828.
Annual General Meeting, p. XXXV (June).
Annual Subscriptions, p. LVIII (Oct.), LXVIII (Dec.).
Associate Fellowship Examination Results, pp. XVII (March), XLVII (Aug.).
Branches and Divisions, pp. VIII (Feb.), XXII (April), XLII (Aug.), LIV (Oct.).
Council 1953-4, pp. XXXIV (June), LXVI (Dec.).
Elections, pp. IV, XI, XX, XXIV, XXXII, XXXVI, XL, XLVII, LI, LVIII, LXIV, LXVII.
Elliott Memorial Prize, pp. XVII (March), XXXIX (June).
Honours Awarded to Members, pp. IV (Jan.), X (Feb.), XXXIX (June), XLIV (Aug.), LVI (Oct.).
Journal Binding, pp. VI (Jan.), XXXVI (June), LII (Sept.).

Lecture Speakers
Allen, N. P., p. 208 (April); Babister, A. W., p. 555 (Sept.); Bailey, G. L., p. 209 (April); Bailey, H. N. D., p. 386 (June); Bailey, S. B., p. 209 (April); Chadwick, R. and Rodgers, J. W., p. 212 (April); Clotworthy, S. E., p. 295 (May); Conway, H. G., p. 296 (May); Dunn, W. H., p. 556 (Sept.); Edwards, G. R., p. 135 (March), p. 210 (April); Ellis, D. L., p. 387 (June); Farren, Sir William, p. 490 (Aug.); Fedden, Sir A. H. Roy, p. 63 (Feb.), p. 211 (April); Forrest, G., p. 211 (April); Greatrex, F. B., p. 555 (Sept.); Hardy, W., p. 293 (May); Heywood, R. B., p. 133 (March); Hickson, V. M., p. 134 (March); Holmes, H. A., p. 296 (May); Howard, H. B., p. 294 (May); Jessop, H. T., p. 136 (March); Jones, E. T., p. 296 (May); Keesing, D. W. G., p. 556 (Sept.); Kerry, F. A., p. 135 (March); King, J. C., p. 296 (May); Knowler, H., p. 76 (Feb.); Lickley, R. L., p. 132 (March); Liddell, I. R., p. 555 (Sept.); Majendie, A. M. A., p. 556 (Sept.); Marshall, J. M., p. 555 (Sept.); Masefield, P. G., p. 76 (Feb.); Murphy, A. J., p. 208 (April); Nutter, J. R., p. 555 (Sept.); Petter, W. E. W., p. 75 (Feb.), p. 387 (June); Pollard, H. J., p. 299 (May); Polli, L., p. 555 (Sept.); Pritchard, J. Laurence, p. 77 (Feb.), p. 133 (March); Reid, W. St. Clair, p. 555 (Sept.); Rowe, N. E., p. 75 (Feb.), p. 388 (June), p. 555 (Sept.); Russell, A. E., p. 294 (May); Scott-Hall, S., p. 76 (Feb.), p. 135 (March); Shenstone, B. S., p. 447 (July); Smout, Sir Arthur, p. 207 (April), p. 210 (April); Sutton, H., p. 211 (April), p. 293 (May); Teed, P. L., p. 212 (April), p. 295 (May); Thurgood, D. A., p. 136 (March); Waterton, W. A., p. 389 (June); Wilkinson, R. G. and Wilson, J. B., p. 297 (May); Wood, W., p. 387 (June).
New Zealand Division, Fourth Annual Report, p. 264 (April). Letter from Hon. Secretary, p. XIX (March).
Prandtl, Ludwig, p. LV (Oct.).
President (1953-4), Sir William Farren, p. XXVIII (May).
Reports, pp. 59, 120, 185, 273, 348, 425, 475, 534, 609, 664, 734, 829.
Scholarships and Awards (details), p. XIV (March).
The Secretary's News Letter, pp. IX (Feb.), XV (March), XXX (May), XLIII (Aug.), LXI (Nov.).

SAUNDERS, C. G. AND L. E. LEAVY
A Modern Wind Tunnel Balance, p. 491 (Aug.).

SAYWELL, G. A. G.
Dimensions Required for Inspection, p. 463 (July).

SHEAR CENTRE
The Centre of Shear of Aerofoil Sections (T.N.), John A. Jacobs, p. 235 (April).
The Flexural Centre or Centre of Shear (T.N.), W. J. Duncan, p. 594 (Sept.).

SHOCK WAVES
See Aerodynamics.

SIBLEY, J. D.
An Introduction to the Helicopter, p. 228 (April).

SMITH, F. AND W. D. T. HICKS
Design of a Simple Electronic Flutter Simulator, p. 29 (Jan.).

STABILITY
A Simple Rolling Method for I_p (T.N.), P. T. Fink, p. 419 (June).

STEPHENSON, B. E.
Fatigue in Aircraft Design, p. 584 (Sept.).

STEPHENSON, J. M.
Elimination of Wall Effects in Axial Flow Compressor Stages (T.N.), p. 241 (April).
Measurement of the Profile Drag of Compressor and Turbine Cascades and the Effect of Wakes in Exciting Vibration (T.N.), p. 722 (Nov.).
On the Stability of Flow of Gas Out of a Compressor (T.N.), p. 345 (May).
Optimum Conditions for the Operation of Airline Aircraft (T.N.), p. 823 (Dec.).

STEVENS, H. L.
Lifing of Aircraft Equipment (T.N.), p. 597 (Sept.).

STILL, E. W.
Temperature Control of Jet-Engined Aircraft, p. 89 (Feb.).

STRAIN GAUGES
A Method of Measuring Post-Yield Strain (T.N.). F. J. Woodcock and K. R. Weiss, p. 49 (Jan.).

STRATFORD, ALAN H.
Optimum Conditions for the Operation of Airline Aircraft (T.N.), p. 524 (Aug.), 824 (Dec.).

STRUCTURES
See also Photoelasticity.
A Method of Calculating Stresses in a Non-Uniformly Thick Disc Subjected to Asymmetric Loads, Adapted to a Tabular Computation (T.N.). B. A. Hodson, p. 658 (Oct.).
Bending of Some Common Beam Sections into the Plastic Range (T.N.). Anthony J. Barrett, p. 110 (Feb.).
Centre of Shear of Aerofoil Sections (T.N.). John A. Jacobs, p. 235 (April).
Deformations and Stresses in Symmetrically Loaded and Circular Plates of Varying Thickness. D. C. Boston, p. 449 (July).
Flexural Centre or Centre of Shear (T.N.). W. J. Duncan, p. 594 (Sept.).
Influence of Edge Conditions and Initial Deflections of a Plate under Normal Pressure (T.N.). S. Eggwertz and A. Norr, p. 343 (May).
Normal Functions of Beam Vibration in Series Solutions of Static Problems (T.N.). R. E. D. Bishop, p. 527 (Aug.).
Pressure Tests on Flat Aluminium Alloy Panels (T.N.). C. J. Dickinson and H. R. Hadley, p. 47 (Jan.).
Stress Analysis of Circular Frames in a Non-Tapering Fuselage. K. J. Dallison, p. 151 (March), p. 268 (April). Technical Note. M. Z. V. Krzywoblocki, p. 600 (Sept.).
Stresses and Deflection in a Flat Plate with Clamped Edges under Normal Pressure (T.N.). J. K. Oaks, p. 244 (April). Correction, p. 422 (June).
Tube of Least Weight for Given Torsional Stiffness (T.N.). H. B. Howard, p. 45 (Jan.).
Unsymmetrical Bending and Bending Combined with Axial Loading of a Beam of Rectangular Cross Section into the Plastic Range. Anthony J. Barrett, p. 503 (Aug.).

SUPERSONIC BANGS
See also Acoustics.
The Noise from Aircraft Travelling with Velocities Greater than that of Sound (T.N.). A. G. Walters, p. 719 (Nov.).

SWEEPBACK
Resolution of Velocity for the Swept-Back Wing at Incidence (T.N.). C. H. McKoen, p. 177 (March).

TATHAM, R.
An Application of Carpet and Lattice Plotting (T.N.), p. 107 (Feb.).

TAYLOR, J.
Measurement of Gust Loads in Aircraft, p. 78 (Feb.).
Structure Weight, p. 646 (Oct.).

TAYLOR, J. LOCKWOOD
The Potential and Field of Flow (Induced Velocity) of a Plane Vortex (T.N.), p. 179 (March).

TAYLOR, R. G.
Compressor Design (T.N.), p. 463 (July).

TAYLOR, W.
Fuselage Lift Distribution for a Swept-Back Wing Aircraft (T.N.), p. 464 (July).

TEED, P. L.
Titanium—A Survey, p. 189 (April).

TEST PILOTS
See A. E. Clouston, W. A. Waterton.

THERMODYNAMICS
The Fluid Mechanics of Detonation Waves. L. G. Dawson, p. 618 (Oct.).

TITANIUM
See Materials.

TOMS, C. F.
Minimum Comfortable Cruising Speed (T.N.), p. 180 (Mar.).

TRAINING
See A. E. Clouston.

TYE, W.
Fatigue—Summary of Discussions, p. 589 (Sept.).
Lifing of Aircraft Equipment (T.N.), p. 597 (Sept.).

TYE, W. AND H. B. CUNDALL
Lifing of Aircraft Equipment and Instruments, p. 391 (June). Technical Notes, p. 597 (Sept.).

WALKER, SIR HUBERT
Ninth British Commonwealth and Empire Lecture—Some Problems in the Development of Air Transport in West Africa, p. 477 (Aug.).

WALKER, P. B.
Design Criterion for Fatigue of Wings, p. 12 (Jan.).
Estimation of the Fatigue Life of a Transport Aircraft, p. 613 (Oct.).

WALTERS, A. G.
The Noise from Aircraft Travelling with Velocities Greater than that of Sound (T.N.), p. 719 (Nov.).

WARNER, J. AND K. J. HEFFERNAN
The Use of Radar to Measure the True Air Speed of an Aircraft (T.N.), p. 653 (Oct.).

WATERTON, W. A.
Some Aspects of High Performance Jet Aircraft, p. 375 (June).

WEIGHT
Structure Weight, J. Taylor, p. 646 (Oct.).

WEISS, K. R. AND F. J. WOODCOCK
A Method of Measuring Post-Yield Strain (T.N.), p. 49 (Jan.).

WESTLEY, R., G. M. LILLEY, A. H. YATES AND J. R. BUSING
Some Aspects of Noise from Supersonic Aircraft, p. 396 (June).

WIND TUNNEL
A Modern Wind Tunnel Balance. L. E. Leavy and C. G. Saunders, p. 491 (Aug.).

WOODCOCK, F. J. AND K. R. WEISS
A Method of Measuring Post-Yield Strain (T.N.), p. 49 (Jan.)

WOODWARD, A. R., G. FORREST AND K. W. GUNN
Fatigue Properties of Z-Section Test Pieces Completely Machined from an Aluminium Alloy Extrusion Conforming to D.T.D.364B. (T.N.), p. 103 (Feb.).

WYLIE, PAUL E.
The Coriolis Effect (T.N.), p. 655 (Oct.).

YATES, A. H., G. M. LILLEY, R. WESTLEY AND J. R. BUSING
Some Aspects of Noise from Supersonic Aircraft, p. 396 (June).

APPOINTMENTS

This section of THE JOURNAL *is available for advertisements of appointments in the Industry, the Ministries, Research Establishments, Universities and Colleges in the United Kingdom only.*

Press Day—20th of the month preceding publication.

Rates—8/- a line. Each paragraph is charged separately and name and address must be counted. Semi-displayed setting £3 0s. 0d. per column inch.

Box Numbers—1/- extra. Replies should be addressed to: Box 000, care of THE JOURNAL, Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

Remittances—Cheques and postal orders should be made payable to the Royal Aeronautical Society.

The Society reserves the right to decline any copy or advertisement at its discretion and accepts no responsibility for delay in publication or for clerical or printer's errors, although every care is taken to avoid mistakes.

SPERRY GYROSCOPE CO. LTD. invite applications from Engineers holding a degree or membership of a professional Institute, for interesting development work on aircraft instrumentation, automatic controls, marine products and guided missiles. Vacancies include:—

ELECTRONIC ENGINEERS for Brentford, Feltham and Gloucestershire. Additional to above qualifications, practical experience and knowledge of production methods with experience of one or more of the following is desirable: Control circuits, D.C. Amplifiers, Computing devices, Video circuits, Microwave techniques.

HYDRAULIC ENGINEERS for Brentford. Essential to have apprenticeship and knowledge of production methods.

MECHANICAL AND ELECTRO-MECHANICAL ENGINEERS for Brentford, Feltham and Gloucestershire. Additional to above qualifications, desirable to have apprenticeship, knowledge of production methods and experience in design of one or more of the following: Gearing, instrument mechanisms, servos.

Pension Scheme

Apply giving full details, including an indication of the salary range and location preferred, to **Personnel Manager, Sperry Gyroscope Co. Ltd., Great West Rd., Brentford, Middx.**

AIRCRAFT DESIGN DRAUGHTSMAN with H.N.C. and several years aircraft experience required for project layout and design study on unusual project. Some stressing knowledge an advantage. A few vacancies for draughtsmen with lower qualifications. Applications to Dept. C.P.S., The English Electric Co. Ltd., 336/7 Strand, London, W.C.2, quoting Ref. No. 1186A.

THE NAVIGATIONAL PROJECTS DIVISION OF THE ENGLISH ELECTRIC CO. LTD., LUTON, require **Technical Supervisory Engineers** for their Projects Offices. Preference will be given to Graduate Engineers who have had some administration experience in the aircraft or associated industries. Structural, Systems and Electronic Engineers with a knowledge of design for production are required. These are senior appointments carrying appropriate salary. In special circumstances, housing assistance will be provided. Applications to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1145A.

THE UNIVERSITY OF MANCHESTER

FLUID MOTION LABORATORY

APPLICATIONS are invited from graduates with some research experience, for the post of **Research Assistant in the Fluid Motion Laboratory.** The person appointed will be required to carry out experimental research on the aerodynamic noise generated by turbulent flows. Salary within the range £450-£600 per annum. Applications should be sent not later than **1st January 1954** to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

THE ENGLISH ELECTRIC CO. LTD., LUTON, require an **Engineer** for work in a section concerned with the preliminary analysis and investigation of the performance of Guided Weapons and their Operational Systems. Candidates for this post should have a good mathematical background allied with strong engineering interest. Experience in this or similar aircraft work or on operations research would be an asset but is not essential. Application to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1043B.

DATA SHEETS ON STRUCTURES

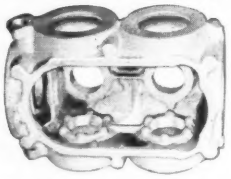
A further issue of new and revised Sheets has just been made. These sheets have been sent to all holders of Structures Data Sheets. Full details of the complete series may be obtained from:—

THE ROYAL AERONAUTICAL SOCIETY
4 HAMILTON PLACE · LONDON W1

ACCLES & POLLOCK LTD.

A&P
Make it with Tubes

AEROPLANE & MOTOR ALUMINIUM CASTINGS LTD.
ERDINGTON, BIRMINGHAM.



ALUMINIUM CAST AUXILIARY DRIVE GEAR BOX

AIRCRAFT MATERIALS LTD.

AML
STRUCTURAL MATERIALS
and COMPONENTS

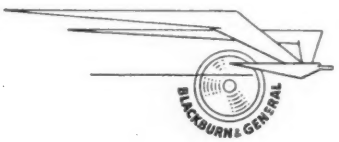
AUTOMOTIVE PRODUCTS CO. LTD.

ALL-BRITISH
Lockheed
hydraulics

BIRMETALS LTD

BIRMETALS

BLACKBURN & GENERAL AIRCRAFT LTD.



BOULTON PAUL AIRCRAFT LTD

BPA

THE BRISTOL AEROPLANE CO. LTD

"Bristol"

BRITISH THOMSON-HOUSTON CO. LTD.

ELECTRICAL B T-H EQUIPMENT
FOR AIRCRAFT

THE DAVID BROWN FOUNDRIES CO

THE DAVID BROWN FOUNDRIES COMPANY
PENISTONE NEAR SHEFFIELD
A DAVID BROWN COMPANY

HIGH TENSILE AND HEAT RESISTING
STEEL CASTINGS FOR AIRCRAFT

DOWTY EQUIPMENT LTD.

DOWTY
UNDERCARRIAGE AND
HYDRAULIC EQUIPMENT

DUNLOP RUBBER CO. LTD.

DUNLOP

DUNLOP

ELECTRO HYDRAULICS LTD.

EH LIMITED

LIVERPOOL ROAD, WARRINGTON

THE ENGLISH ELECTRIC CO. LTD., LONDON

'ENGLISH ELECTRIC'

MANUFACTURERS OF AIRCRAFT,
AIRCRAFT ELECTRICAL EQUIPMENT,
WIND TUNNEL DRIVES, TEST PLANTS FOR
RECIPROCATING AND TURBINE-TYPE ENGINES,
SUPERCHARGERS, COMPRESSORS, ETC.

FIRTH-VICKERS STAINLESS STEELS LTD.

"Stayrite Steel"

FOLLAND AIRCRAFT LTD.

FOLLAND AIRCRAFT LTD

HAMBLE, SOUTHAMPTON

HANDLEY PAGE LTD.

HP

H. M. HOBSON LTD

Hobson

THE HUGHES-JOHNSON STAMPINGS LTD.

JH

IMPERIAL CHEMICAL INDUSTRIES LTD. (Metals Division)

ICI

INTEGRAL LTD.

INTEGRAL LTD.
HYDRAULIC PUMPS
AND EQUIPMENT

IRVING AIR CHUTE OF GREAT BRITAIN LTD.

AIR CHUTES IRVIN

KELVIN & HUGHES (AVIATION) LTD.

KH

(HENRY HUGHES & SON LTD.
KELVIN, BOTTOMLEY & BAIRD LTD.)

K.L.G. SPARKING PLUGS LTD.

K·L·G

SPARKING PLUGS AND
IGNITION EQUIPMENT

SMITHS AIRCRAFT INSTRUMENTS LTD.

SMITHS

SMITHS AIRCRAFT INSTRUMENTS LTD

A. V. ROE & CO. LTD.

AVRO

LIGHT-METAL FORGINGS LTD.

LMF

ROLLS-ROYCE LTD

ROLLS-ROYCE

AERO-ENGINES

JOSEPH LUCAS (GAS TURBINE EQUIPMENT) LTD

LUCAS

ROTAX LTD

ROTAX

AIRCRAFT ELECTRICAL ENGINEERS

MARTIN-BAKER AIRCRAFT CO. LTD.

M-B

ROYAL AERONAUTICAL SOCIETY

DATA SHEETS
MONOGRAPHS

D. NAPIER & SON LTD.

N

SAUNDERS-ROE LTD.

SARO

SAUNDERS-ROE LTD.
OSBORNE, EAST COWES, ISLE OF WIGHT
Telephone: Cowes 445

PERCIVAL AIRCRAFT LTD

SELF-PRIMING PUMP AND ENGINEERING CO. LTD.

SPECIALISTS
in
Aircraft Fuel Line Equipment

SERCK RADIATORS LTD.

SERCK

TELEFLEX PRODUCTS LTD.

TELEFLEX MECHANICAL REMOTE CONTROLS

SHORT BROTHERS & HARLAND LTD.

Shorts

Established 1908

THE FIRST MANUFACTURERS OF AIRCRAFT IN THE WORLD

VOKES LTD.

AMBER CROSS
Trade Mark
Symbol of complete protection by Vokes Filters

THE SPERRY GYROSCOPE CO. LTD.

SPERRY

WESTLAND AIRCRAFT LTD.

WESTLAND
S.55 and S.51 HELICOPTERS
WESTLAND AIRCRAFT LTD YEOVIL ENGLAND

CHANGES OF ADDRESS

Changes of address should be notified promptly to ensure delivery of the Journal.
When notifying changes please give the following particulars:—

1. Name (in block letters).
2. Grade of membership.
3. New address (in block letters).
4. Old address.

This information should be sent to:

The Secretary

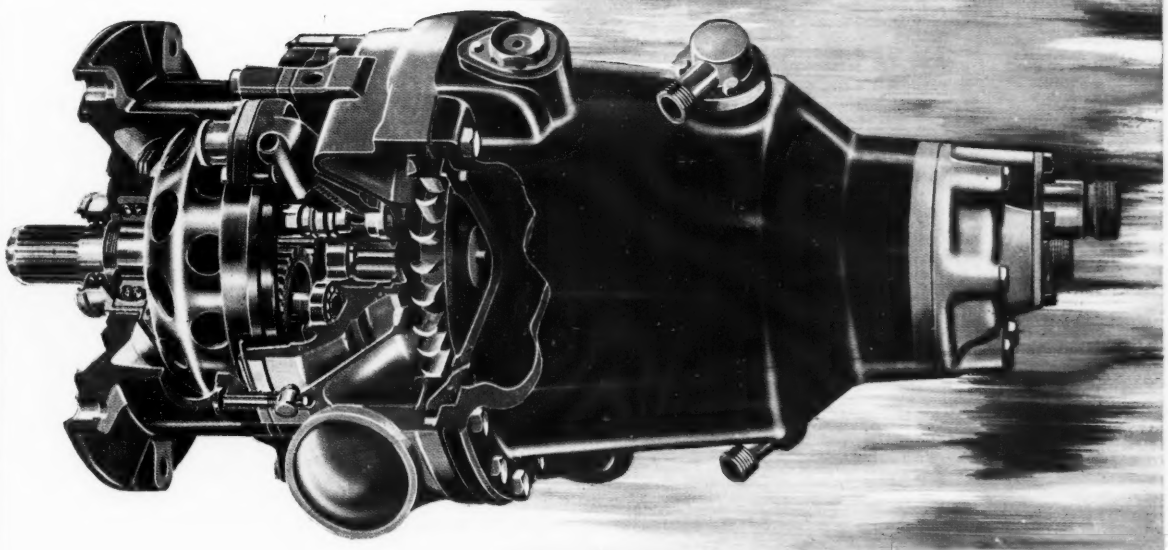
THE ROYAL AERONAUTICAL SOCIETY, 4 HAMILTON PLACE, LONDON, W.1

DIRECTORY OF ADVERTISERS

Accles & Pollock Ltd.	Paddock Works, Oldbury, Birmingham	Broadwell 1500
Aeroplane & Motor Aluminium Castings Ltd.	Wood Lane, Erdington, Birmingham	Erdington 2207-9
Aircraft Materials Ltd.	Midland Road, London, N.W.1.	Euston 6151
Automotive Products Co. Ltd.	Tachbrook Road, Leamington Spa	Leamington Spa 2700
Birmetals Ltd.	Woodgate Works, Quinton, Birmingham, 32	Woodgate 2253
Blackburn and General Aircraft Ltd.	Head Office: Brough, E. Yorks	Brough 121
	London Office: 43 Berkeley Square, W.1	Grosvenor 5771-8
Booth, James, Ltd.	Argyle Street, Nechells, Birmingham 7	East 1521
Boulton Paul Aircraft Ltd.	Wolverhampton, Staffs	Fordhouses 3191
Bristol Aeroplane Co. Ltd., The	Filton House, Bristol	Filton 3831
British European Airways Corporation	Keyline House, Northolt, Middlesex	Waxlow 4334
	Dorland Hall, Lower Regent Street, London, S.W.1	Gerrard 9833
British Messier Ltd.	Cheltenham Road East, Gloucester	Churchdown 3281
British Overseas Airways Corporation	Head Office: Airways House, Great West Road, Brentford	Ealing 7777
	Traffic Enquiries: Airways Terminal, Buckingham Palace Road, S.W.1	Victoria 2323
British Thomson-Houston Co. Ltd.	Lower Ford Street, Coventry	Coventry 64181
Burgess Products Co. Ltd.	Micro Switch Division, Dukes Way, Team Valley, Gateshead 11	Low Fell 75322-4
Camerer Cuss	54-56 New Oxford Street, London, W.C.1	Museum 7313
Chemical and Insulating Co. Ltd.	Darlington, Co. Durham.	
David Brown Foundries Company	Penistone, near Sheffield	Penistone 135
de Havilland Aircraft Co. Ltd., The	Hatfield Aerodrome, Herts.	Hatfield 2345
de Havilland Propellers Ltd.	Lostock, Bolton, Lancs.	Horwich 480
Douglas Aircraft Ltd.	3,000 Oran Park Blvd., Santa Monica, California, U.S.A.	
Dowty Equipment Ltd.	Cheltenham, Glos.	Cheltenham 53471
Dowty Fuel Systems Ltd.	Cheltenham, Glos.	Cheltenham 53471
Dunlop Rubber Co. Ltd. (Aviation Divn.)	Holebrook Lane, Foleshill, Coventry	Coventry 88733
Electro - Hydraulics Ltd.	Liverpool Road, Warrington	Warrington 2244
English Electric Co. Ltd.	Queens House, Kingsway, London, W.C.2	Holborn 6966
	Stafford	Stafford 700
Esso Petroleum Co. Ltd.	36 Queen Anne's Gate, London, S.W.1	Whitehall 5151
Fairey Aviation Co. Ltd.	Hayes, Middlesex	Hayes 3800
	24 Bruton St., London, W.1	Mayfair 8791
Firth, Thos. and John Brown Ltd.	Atlas Works, Sheffield, 4	Sheffield 26081, 26491
	11 Hamilton Place, London, W.1	Grosvenor 8781-6
Firth - Vickers Stainless Steels Ltd.	Staybrite Works, Sheffield	Sheffield 42051
Flight Refuelling Ltd.	5 Clarges Street, London, W.1	Grosvenor 5741
	Tarrant Rushton Airfield, Blandford, Dorset	Blandford 501
Folland Aircraft Ltd.	Hamble, Southampton, Hants.	Hamble 3191
General Electric Co. Ltd.	Magnet House, Kingsway, London, W.C.2	Temple Bar 8000
Graviner Manufacturing Co. Ltd.	(Aircraft Divn. Sales Dept.), Poyle Mill Works, Colnbrook, Bucks.	Colnbrook 48-49
Handley Page Ltd.	Cricklewood, London, N.W.2	Gladstone 8000
Hawker Aircraft Ltd.	Kingston-on-Thames	Kingston 1044
Hawker Siddeley Group Ltd.	18 St. James's Square, London, S.W.1	Whitehall 2064
High Duty Alloys Ltd.	Slough, Bucks.	Slough 23901
Hobson, H. M., Ltd.	Hobson Works, Fordhouses, Wolverhampton	Fordhouses 2266
Hughes-Johnson Stampings Ltd., The	Langley Green, Birmingham	Broadwell 1361
Imperial Chemical Industries Ltd.	Nobel House, 2 Buckingham Gate, London, S.W.1	Victoria 4444
Imperial Chemical Industries Ltd. (Alkali Division)	Winnington, Northwich, Cheshire	Northwich 4444
Imperial Chemical Industries Ltd. (Metals Division)	Kynoch Works, Witton, Birmingham, 6	Birchfield 4848
Integral Ltd.	Birmingham Road, Wolverhampton	Wolverhampton 24984
Irving Air Chute of Great Britain Ltd.	Ickneild Way, Letchworth, Herts.	Letchworth 888
Kelvin & Hughes (Aviation) Ltd.	New North Road, Barkingside, Essex	Hainault 2601
K.L.G. Sparking Plugs Ltd.	Putney Vale, London, S.W.15	Putney 2671
Light-Metal Forgings Ltd.	Oldbury, Birmingham	Broadwell 1152
Joseph Lucas (Gas Turbine Equipment) Ltd.	Shaftmoor Lane, Birmingham, 28	Springfield 3232
	Burnley	Burnley 5051 & 5027
Low Moor Alloy Steelworks Ltd.	Low Moor, Bradford	Low Moor 663
Magnesium Elektron Ltd.	Lumm's Lane, Clifton Junction, nr. Manchester	Swinton 2511-9
	Bath House, 82 Piccadilly, London, W.1	Grosvenor 6300
Marston Excelsior Ltd.	Wolverhampton	Fordhouses (W'ton) 2181
	49/59 Armley Road, Leeds, 12	Leeds 37351 Armley 38081-5
Martin-Baker Aircraft Co. Ltd.	Higher Denham, Bucks	Denham 2214
Napier, D., & Son Ltd.	Acton, London, W.3	Shepherds Bush 1220
Normalair Ltd.	West Hendford, Yeovil, Somerset	Yeovil 1100
Percival Aircraft Ltd.	Luton Airport, Luton, Beds.	Luton 6060
Pitman, Sir Isaac & Sons Ltd.	Parker Street, Kingsway, London, W.C.2	Holborn 9791
Plessey Co. Ltd., The	Vicarage Lane, Ilford, Essex	Ilford 3040
Qantas Empire Airways	69 Piccadilly, London, W.1	Mayfair 9200
Roe, A. V., & Co. Ltd.	Greengate, Middleton, Manchester	Failsworth 2020-2039
Rolls-Royce Ltd.	Derby	Derby 42424
	14-15 Conduit Street, London, W.1	Mayfair 6201
Rotax Ltd.	Willesden Junction, London, N.W.10	Elgar 7777
Rotol Ltd.	Cheltenham Road, Gloucester	Gloucester 24431
Saunders-Roe Ltd.	Head Office: Osborne, E. Cowes, Isle of Wight	Cowes 445
	London Office: 45 Parliament Street, Westminster, S.W.1	Whitehall 7271
Saunders Valve Co. Ltd.	Cwmbran, Newport, Monmouthshire	Cwmbran 3281-3
Self-Priming Pump & Engineering Co. Ltd.	Edinburgh Avenue, Trading Estate, Slough, Bucks.	Slough 23277
Serck Radiators Ltd.	Warwick Road, Birmingham, 11	Victoria 0531
Shell-Mex and B.P. Ltd.	Shell-Mex House, Strand, London, W.C.2	Temple Bar 1234
Short Brothers and Harland Ltd.	Seaplane Works, Queen's Island, Belfast	Belfast 58444
Smiths Aircraft Instruments Ltd.	Cricklewood Works, London, N.W.2	Gladstone 3333
Sperry Gyroscope Co. Ltd., The	Great West Road, Brentford, Middlesex	Ealing 6771
Standard Telephones and Cables Ltd.	Connaught House, Aldwych, London W.C.2	Holborn 8765
Teleflex Products Ltd.	Teleflex Works, Chadwell Heath, Essex	Seven Kings 5771-7
Tungum Co. Ltd.	Brandon House, Painswick Road, Cheltenham, Glos.	Cheltenham 5856
Vickers - Armstrongs Ltd.	Vickers House, Broadway, Westminster, S.W.1	Abbey 7777
	Weybridge Works, Weybridge, Surrey	Byfleet 240-243
	Supermarine Works, Hursley Park, Winchester, Hants.	Chandlersford 2251
Vokes Ltd.	Henley Park, nr. Guildford, Surrey	Guildford 62861
Wakefield, C. C., & Co. Ltd.	46 Grosvenor Street, London, W.1	Mayfair 9232
Westland Aircraft Ltd.	Yeovil, Somerset	Yeovil 1100

The Plessey

LIQUID FUEL STARTING SYSTEM



. . . for low cost—high speed starting

The first...

liquid propellent starting system to complete a Bench Type Test

The Plessey Liquid Fuel Starting System is designed as a lightweight installation operating on an inexpensive, safe fuel which is readily available.
Approximate costs per start would vary between 4/- for current engine types to 7/- for larger types of engine now under development.
The starter motor would normally be installed as an engine auxiliary — the associated equipment being distributed conveniently nearby.
The system can achieve an engine idling speed within 10 seconds and is controlled from a single push-button.
Consecutive starting of multiple engines can be arranged.

THE PLESSEY COMPANY LIMITED · ILFORD · ESSEX

A3

PRINTED BY THE LEWES PRESS (WIGHTMAN & CO. LTD.), LEWES, SUSSEX, ENGLAND, AND PUBLISHED BY THE ROYAL AERONAUTICAL SOCIETY, 4 HAMILTON PLACE, LONDON, W.1, ENGLAND.